Technical assessment of communal irrigation systems in Luzon

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As of December 2014, about 1.708 million hectares (M ha) or 56.6 percent of the total irrigable area in the Philippines have been developed for irrigation. Of these, 595,653 ha or 34.9 percent are under farmer-managed communal irrigation systems (CIS) (NIA, 2014). CIS represent just about 20 percent of the 3.1 M ha of potential irrigable areas based on the National Irrigation Administration (NIA) estimates, and a mere 10 percent of the 6.1 M ha based on a World Bank (1991) study. This illustrates an opportunity and the need to develop CIS, particularly in areas not feasible for national irrigation systems (NIS).

Despite increasing investments, the firmed-up service area (FUSA) of CIS at the national level only increased by about 6 percent over the last 10 years. Likewise, despite massive rehabilitation efforts and funds for construction of new irrigation facilities, the increase in irrigation area is minimal. From 1995 to 2005, the rate of increase in the actual NIS and CIS service areas is only about 10,000 hectares per year (ha/yr), while the annual deterioration rate is about 134,000 ha/yr (David 2009, 2012). From 2006 to 2013, the newly generated and rehabilitated areas averaged about 24,000 ha and 140,000 ha/yr, respectively. According to David (2003), the latter is double the value of the rehabilitated area before the Agriculture and Fisheries Modernization Act, which was from 1992 to 1996. The reasons cited include design mistakes, poor construction, neglect in operation and maintenance (O&M), and
shifting hydrographs (i.e., charts that show the rate of water flow over time) as a result of the degradation of critical watersheds. Moreover, design flaws are not being rectified during rehabilitation.

The national average cropping intensity of CIS is about 130 percent. Meanwhile, the efficiency of irrigation water use is between 30 and 40 percent. This low cropping intensity is due to over assessment at the design stage of the individual system service area relative to what is actually irrigated and to available water supply (World Bank 1990).

This Policy Note examines the common technical problems associated with the construction and O&M of CIS based on a study of 66 CIS in 11 provinces in Luzon. These CIS collectively cover a FUSA of about 332,769 ha, representing 58 percent of the total CIS in the Philippines as of 2013. The specific technical concerns examined include the sources of water, sedimentation, and design considerations from headworks to the distribution systems of CIS.

Sources of water
The lack of water supply during the dry season is one of the major reasons for the low performance of CIS, which is a direct result of inadequate water resources database. Hence, water supply pattern (i.e., the daily and seasonal variability of the flow) is the most critical factor in considering the choice and design of an irrigation system. It is also the major determinant in the selection of a project’s operational objectives: equity, reliability, timeliness, efficiency, and flexibility. The sources of water of the surveyed CIS include one or a combination of the following: lakes, rivers, creeks, springs, groundwater, and runoff.

Of the 66 CIS surveyed, only 22 or 33 percent have river sources that were deemed capable of providing irrigation even during dry seasons. Eight of these rivers have published historical records; however, data from these records indicate decreasing dependable flows. Four of these rivers are considered large, providing water to large NIS and to CIS through large pumps or gravity systems. In some CIS, portions of the system are not planted in the wet season due to flooding.

In 14 CIS, creeks are the major source of water. These creeks have adequate water flow for small areas during the wet season. However, during the dry season, they produce extremely low flow or, at times, no flow at all. In fact, two of these creeks (i.e., Arimal and Pangul Creeks) have no flow during the site visit. According to the irrigators associations (IAs) interviewed, the forests that support the watershed are already denuded due to slash-and-burn agriculture or kaingin.

Springs, meanwhile, are the principal water sources of most CIS in Benguet and in three other CIS. However, because spring discharges are usually low, they are supplemented by other sources like flows from creeks and runoff (e.g., San Angel SRIP). There are three other
CIS that rely on excess runoff either as the main source or in support of other principal water sources. These CIS are equipped with costly storage reservoir dams to impound water, but they can only support small areas for irrigation.

Most of the IA members interviewed have shallow tubewell (STW) pump sets serving as a supplemental water source in times of inadequate or intermittent irrigation from the canal systems, or as a primary water source for vegetables or other high-value crops. Most STWs are owned by the farmers and are purchased under their own initiatives. Some CIS, meanwhile, are directly irrigated by NIA-funded STWs, such as the Viola Estate CIS and Cabaruan Communal Pump Irrigation System (CPIS) in Isabela, and the San Roque Pump Irrigation System (PIS) in Victoria, Laguna.

**Sedimentation**

The NIA recognized sedimentation in the storage area of dams and in the canals as another reason for the low performance of irrigation systems, thus, it proposed a catchment Management Component (NIA 1996) to the World Bank-assisted Water Resources Development Project. These sediments—which came from sidehills, drainage/creeks, side slopes of irrigation canals, and catchment—were all observed in the CIS visited. It was in the catchment, however, where the bulk of sediments came from, especially when the forest covers have been denuded or if kaingin is being practiced. Despite high sedimentation rate, the IAs rated low silt level grade and undesired seepage grade in their canals. Because CIS canals are smaller and more manageable than NIS, the IAs can regularly clean their canals, hence, the low grade in silt level and seepage.

A specific case is the Anao CIS dam along the Abakan River in Pampanga, which was affected by lahar that caused reduction in its storage capacity. The quarrying problem in the upstream and downstream areas of the dam was one of the causes of the tilting or the collapse of the previous dam. According to the CIS design manual, there should be no quarrying of the river within 1 kilometer in the upstream and downstream areas of a proposed diversion dam.

There were no silt control devices found during the field visits because their provision is not included in the CIS design manual of the NIA. The estimation of sediment load discharge of the river source was also not conducted during the project feasibility phase. The NIA conducted two sedimentation studies in North Cotabato. A study in the Malasila River Irrigation System (RIS) pointed out that silt excluder (Figure 1) reduced the intrusion of sediment in the main canal. Meanwhile, in the Mlang RIS, the provision of a settling basin and silt ejector (Figure 2) reduced the yearly rehabilitation costs, specifically in dredging activities or canal desilting.

**Technical design considerations**

Low irrigation efficiency is caused by the following: (1) deterioration of canals and
related facilities due to lack of maintenance; (2) insufficient water control facilities, including discharge measuring devices; and (3) high water conveyance loss in the unlined canals. As a result, the collection of irrigation service fees is low and inefficient. Based on the interviews with the IA officers/members and walkthroughs in some systems, the following are some technical issues confronting the IAs and the performance of their CIS.

**Dam design**

The dams of the CIS visited are old, with exposed rock cores, damaged spillways, and silted storage area. The dam designs are simple with some ogee-type spillways, gated weirs, and gabions. Despite persistent request for the feasibility study of the selected CIS, no information or any documentation on their design was given. Without the requested feasibility studies, it may be assumed that the simpler design of CIS dams compared to NIS is due to the relatively low river flows; budget limitations were also considered. It is also possible that these systems were constructed either by relying on old design criteria or adopting design parameters from neighboring systems. The following are some specific examples.

The Anao CIS dam (Figure 3) was the second dam built in the lahar-laden Abakan River, after the previous dam tilted due to scouring at the downstream area of the dam. The dam needs major rehabilitation to prevent another tilting or possible collapse, which can cost
around PHP 70 million. Quarrying activities in the downstream area of the dam should then be stopped so as not to compromise the stability of the dam.

Meanwhile, the Cordero dam (Figure 4) in Nueva Ecija is made up of gabions, which are plastered with concrete. Including the lined canals, the dam cost PHP 4.4 million. However, it is now completely filled up with sediments that almost reach the dam crest level, which, according to the IA, occurred just after three heavy rainfalls. Another heavy rain and the sediments may overtop the dam. The dam seems to be haphazardly designed and constructed, without considering the river flow records and sediment discharge.

Lastly, the San Angel Small Reservoir Irrigation Project (Figure 5) in Pangasinan is an earth-filled dam that stores water from two spring sources and runoff. It was designed to irrigate 160 ha, but only about half of it is irrigated during the dry season. According to the acquired map, the project cost PHP 79 million, but the IA said the project is worth PHP 150 million. Hence, it is deemed overdesigned and too costly for irrigating a relatively small area.

**Sluice and intake gates**

Most of the surveyed CIS have broken or defective sluice and intake gates, which were replaced by flashboards, sand bags, or rocks. In some CIS, the lifting mechanisms are also defective. In these CIS, the sediments are almost at the crest of the dam, reducing its...
storage capacity. These should be repaired to ensure proper control of water and sediment intake. If the sluice gates are always closed, more sediments will either be trapped upstream of the dam or be entering into the system. If the intake gates are always open, meanwhile, sediment entry into the system, as well as the occurrence of flooding in the fields during high-river flows, cannot be avoided.

**Canal networks**
Most of the CIS visited have lined main canals; in some, the laterals are also lined.

This is because the relatively small FUSA and the simple design of the dams allow for more funds to be used in the lining of the canals. Canal conditions depend on whether the IAs have good O&M and cleanup activities. Siltation is a major problem but, usually, IAs manage to clean the canals themselves.

**Water control, measurement, and miscellaneous structures**
Because of low discharge capacity, only simple water control structures are found in most CIS. While some are well-maintained, others have deteriorated and are not functioning well or as originally intended. Based on the key informant interviews (KIIIs) conducted, IAs considered the cross regulators to be in good condition and easy to operate. However, there are not enough check gates to ensure adequate water level control in every outlet.

Water measurement is essential to effective water management. In all the CIS visited, any form of flow measurements is only done at the headworks; even then, these are only based on staff gage readings and rating curves, which are either missing or have not been recalibrated since the CIS construction.

Other miscellaneous structures commonly found in all the CIS include road and thresher crossings, end checks, and service roads. Based on the KIIIs, IAs rated the availability of roads along canals as poor because they are rough, with most dams accessible only by walking or by motorcycles.
Conclusion and recommendations
The problem of lack of water during the dry season is more evident in CIS, which often rely on small ungauged rivers and creeks for water supply. This unreliable flow causes unbalanced water distribution where farmers near the head gates often take the bulk of water without considering the water requirement and schedule of delivery of those in the downstream. If there is no water management scheme in place, or if a water scheduling agreement is not properly implemented, downstream farmers suffer. As such, because of unreliable water supply and inadequate irrigation water management, irrigated areas in both wet and dry seasons are smaller and crop yields lower than expected.

When the water supply is unreliable, it also becomes difficult to organize farmers and motivate them to participate in O&M duties. Moreover, they are less willing to pay irrigation service fee if the service is poor. When maintenance activities are deferred because of neglect or inadequate funds, operational problems worsen and result in a rapid deterioration of the system, including failure of canal lining and malfunctioning of control structures. Fortunately, the CIS IAs are still optimistic on their irrigation system as evident on their positive response to the KII. But these results also showed that there are still much room for improvement.

On the problem of water supply sources, the NIA through its regional irrigation offices should collate all historical or generated synthetic streamflow data from other government agencies (e.g., Bureau of Research Standards of the Department of Public Works and Highways and Bureau of Soils and Water Management [BSWM] of the Department of Agriculture), the academe, and other project-based studies (e.g., Project-NOAH of the Department of Science and Technology [DOST], River Basin Control Office.

Figure 5. (a) The reservoir dam of the San Angel SRIP storing water from springs and runoff, (b) the concrete spillway of the CIS (Photos by Engr. Rory Abance, NIA)
[RBCO] Master Plans of the Department of Environment and Natural Resources (DENR) to identify potential sites for diversion dams and storage reservoirs. There should be a strict adherence to the CIS design manual and NIA general guidelines for project identification, including more stringent evaluation and approval of proposed CIS projects, in order to make sure that there will be enough water supply many years after the project has been completed. In rivers with high wet season flows and low dry season dependable flows, construction of storage or reservoir dams is a viable long-term solution to mitigate the problem of seasonal irrigation and help improve the reliability of irrigation water supply; however, they should be economically, environmentally, socially, and technically feasible.

The estimation of dependable (low) water supply and flood (high) discharges for rivers, potentially viable for reservoir and/or diversion dams, is very important. Streamflow data should be checked for consistency and reliability, including the effect of changing land use and climate change on the inflow and flood hydrographs.

Improvements in hydrologic data acquisition and monitoring are also warranted. Estimation of sediment discharge should be included in the standard river flow measurement, in light of the escalating erosion of watersheds. With the current setup of the National Water Resources Board, they have limited capability and manpower to do this. The shelved proposal for the institution of the National Water Resources Management Office under the Office of the President should be revived and reformulated, including the institution of Water Resources Centers based on selected state universities and colleges, which can continuously gather, analyze, and manage water resources data. The master plans for the 18 major river basins, commissioned by the RBCO of DENR (2012), may be tapped for this purpose. These master plans include water balance studies and projections of flows of some rivers, which may be used for irrigation water supply.

Together with this, there is a need to continually assess surface water potentials for irrigation and other uses. These should be done to facilitate the proper identification and zoning of potentially irrigable areas by gravity systems (i.e., NIS, CIS, and small water impounding projects [SWIPs]) or by pumps (i.e., STWs and low-lift pumps/open surface pumps [LLPs/OSPs]). This would help the NIA and the BSWM delineate which areas should be irrigated by NIS, CIS, SWIPs, and STWs. The NIA should also be aware of the different projects and initiatives by other government agencies (e.g., UP Diliman Phil-LiDAR 2 Project 1: Agricultural Resources Assessment using LiDAR and other Remote Sensing Data) and forge some partnerships or collaborations with them to help improve project identification and planning.
The Philippines has about 5 M ha of shallow aquifers, which are underground formations with water that can be economically developed for pumping. Based on available groundwater potential maps, it was found that a large part of the CIS areas visited are underlain with good shallow aquifers. However, the existing groundwater maps were based on the limited number of wells in the 1980s. There is a need to conduct an up-to-date aquifer characterization to provide information on the location of shallow well areas, as well as the lithologic (i.e., depth and thickness of aquifers), hydraulic (i.e., hydraulic conductivity, transmissivity, storage coefficient, and specific yield), and hydrologic properties (i.e., safe yield) of aquifers. This will also guide farmers or IAs if STWs would be feasible and where they should be sited in their areas, either as primary source or as supplemental irrigation. In most of the CIS visited, farmers resorted to the conjunctive use of CIS and STWs. This practice should be supported with related programs, such as trainings on the design, drilling, and well development of STWs, proper O&M of STWs, engine troubleshooting and repairs, water management, and crop diversification.

Sedimentation is one of the main problems that causes canal deterioration and decrease in water yield during dry season. The IAs in the CIS visited manage to limit sedimentation in the canals through regular cleaning, but the bulk of the sediment problem is on the storage area of the dams. Provision of silt control devices, either in the headworks or in the main or lateral canals, should be included in the design, especially for sediment-laden rivers or creeks. If large bed loads, including rocks and boulders, are present upstream of rivers, the use of Sabo dams (i.e., dams built to minimize the effect of lahar and volcanic mudflow) may be employed. But there should also be a watershed protection program in place.

In case of rehabilitation work, existing systems must be checked for design shortcomings and relate these to the O&M of such systems. The design shortcomings of several dams, specifically the Anao CIS dam, Cordero CIS, and San Angel SRIP, should be avoided to prevent such mistakes in the future. These shortcomings include (1) underestimation of flood flows and sediment loads, (2) inadequate provisions for sediment control, and (3) underestimation of reservoir inflow and outflow hydrographs. Generally, the dams and control structures should be properly maintained and repaired to ensure proper water control and distribution. The dam storage area should also be regularly cleared of sediments to increase storage capacity and, thus, extend irrigation even with diminished river flows. This should be part of regular O&M activities of the IAs. If heavy equipment are necessary, the NIA should extend help to the IAs.

In CIS where the dry season flow cannot support anymore the dry season irrigation
requirements, the IA may consider crop diversification (i.e., planting nonrice crops or crops requiring less water), particularly in areas at the tail end of the system. If they still prefer rice, direct seeding could be considered to minimize water use from conventional land soaking and land preparation. Water management and soil-water conservation technologies, such as alternate wetting and drying and zero tillage, should also be promoted.

References


