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Assessing the Resurgent Irrigation Development Program of the Philippines – National Irrigation Systems Component

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Abstract

This Project focused on the evaluation of National Irrigation Systems (NIS) in the Philippines which consisted of 22 NIS in Luzon and 17 NIS in Visayas and Mindanao and are represented by 151 Irrigators Associations (IAs). The overall objective is to evaluate the policy, programmatic, and institutional framework governing irrigation development and management for the main purpose of improving irrigation performance and productivity of irrigated lands. The methodological approach to meet the specific objectives consisted of data collection through site visits, field measurements, and Key Informant Interviews (KII) and Focus Group Discussions (FGDs). These are part of the Rapid Appraisal Procedure (RAP) of MASSCOTE where most of the questions are derived. Also, Geographic Information System (GIS) analysis was applied to map location of surveys, structures and point measurements as well as to perform spatial analysis of erosion, groundwater potential, and performance levels of the NIS cases at the IA level. Principal Component Analysis (PCA) was implemented to assess the performance of the NIS cases considered at the IA level using four major categories (Technical/Physical, Institutional/Organizational, Economic and Environmental) of indicators. The primary and secondary data collected are associated with these indicators which include water supply and quality, conditions of irrigation structures and canals, IAs profile, degree of satisfaction on water delivery, irrigation service fee (ISF) collection (in Luzon), maps of service areas, erosion and ground water potential maps, NISPER data, among others. Results showed that siltation problems exist in canals of almost all NIS cases, causing reduced flow capacities that deprived the downstream portion from adequate water supply. Conveyance efficiency is low in some systems especially in unlined (earth) canals where water losses are high due to seepage and percolation. Irrigation service is adversely affected by illegal settlers, dumping of garbage, and illegal pumping. On the environmental aspect, water quality as characterized by pH, DO, and EC are reasonably good in most systems where pH is on the neutral side (5 to 7), DO is > 6ppm, and EC < 300uS/cm. On the institutional side, free ISF was introduced in 2017 and it seems to favor farmers since they can use the savings for other purposes. But some IAs complain that without ISF, funds are limited for maintaining canals and thus causing poor water delivery. Also, the integrated analysis has shown that ISF has positive effect on the irrigation performance index (IPI), thus IAs in Luzon seem to perform better than IAs in Visayas and Mindanao where most of the low performing IAs were located. To improve performance of irrigation systems, good watershed management is needed as a preventive approach to address siltation of water courses and thus enhance water supply distribution. The National irrigation Administration (NIA) should allocate realistic resources for operation and maintenance to improve efficiency in water allocation and distribution from upstream to downstream users. GIS techniques are a potentially valuable tool for NIS design and management. However, inadequate data is a constraint that limits comprehensive assessment and management of NIS.

List of Abbreviations

AFMA – Agriculture and Fisheries Modernization Act
BPIS – Banaoang Pump Irrigation System
BSWM – Bureau of Soils and Water Management
CIS – Communal Irrigation System
CO – Central Office
DEM – Digital Elevation Model
DO – Dissolved Oxygen
EC – Electric Conductivity
FA – Farmer's Association
FGD – Focus Group Discussion
FUSA – Firmed-up Service Area
GIS – Geographic Information System
IA – Irrigator's Association
IDO – Irrigation Development Officer
IMO – Irrigation Management Office
IMT – Irrigation Management Transfer
IPI – Irrigation Performance Index
ISF – Irrigation Service Fee
KII – Key Informant Interview
KMO – Kaiser Mayer Olkin
LGU – Local Government Unit
LIPA – List of Irrigated and Planted Areas
MARIIS – Magat River Integrated Irrigation System
MASSCOTE – Mapping System and Services for Canal Operation Techniques
NIA – National Irrigation Administration
NIS – National Irrigation System
NISPER – National Irrigation System Performance
O&M – Operations and Maintenance
PCA – Principal Component Analysis
PCD – Pollution Control Department
PDRIS – Pampanga Delta River Irrigation System
RAP – Rapid Appraisal Procedure
RIO – Regional Irrigation Office
RIS – River Irrigation System
SWIP – Small Water Impounding Project
SWRFT – Senior Water Resources Facilities Technician
TDS – Total Dissolved Solids
TGIS – Tarlac Groundwater Irrigation System
UPRIIS – Upper Pampanga River Integrated Irrigation System

Table of Contents

List of tables

List of Figures

Assessing the Resurgent Irrigation Development Program of the Philippines – National irrigation systems component

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1. Background and Brief Description of the Project

The government through the National Irrigation Administration (NIA) undertakes the planning, construction, O&M, and rehabilitation of national irrigation systems (NIS), which are mostly run-of the-river gravity systems, though a few systems use large pumps to extract water from major river systems. The NIS are typically more than 1000 hectares (has) in size, with the largest three systems with water reservoirs for dry season cropping having service areas ranging from about 30,000 to 110,000 has. They presently number close to 220 systems with a total firmed up service area of about 723,000 has and have accounted for approximately 78% of government capital outlays for irrigation from 1966 to 2012. However, the NIS accounted for only 47% of government's capital outlays for irrigation from 2008 to 2012, much lower than the overall average as greater budgets were allocated for communal and other smaller irrigation systems in recent years. Also, while irrigation service fees are collected from farmers, these do not cover any of the capital cost nor the full cost of operation and maintenance.

The project aims to evaluate the effectiveness, impact, and efficiency of the government's irrigation program. Irrigation is firmly ensconced in key legislations for agriculture in the Philippines, namely Magna Carta of Small Farmers (RA 7607) and the Agriculture and Fisheries Modernization Act or AFMA (RA 8435). The project aims at providing a set of recommendations for public irrigation projects. It is the second phase of an appraisal initiated in 2013-2014, whose output is a series of Policy Notes and a Discussion Paper of the Philippine Institute for Development Studies. For this phase, the study focuses on three components: i) assessment of NIS towards improved governance; ii) rapid appraisal of communal irrigation systems (CIS); and iii) cross-cutting issues.

The three types of irrigation are distinguished by its size in terms of service area, source of water, technology of water extraction and distribution, and the nature of governance. The government, through the National Irrigation Administration (NIA), undertakes the planning and design, project selection, operation and maintenance, repair, restoration, and rehabilitation of national irrigation systems. And though irrigation service fees are collected from farmers, revenues are generally less than the cost of operation and maintenance, while the government finances all of the capital cost of irrigation construction, repairs, and rehabilitation. By the late 1980s, irrigators' associations have been developed to undertake some of the operation and maintenance functions in NIS.

National irrigation systems are defined to be those with service areas that are 1000 has and above, with the largest reaching slightly more than 100,000 has, though a small number are currently less than the threshold size. There are about 217 national irrigation systems with a total service area of 770,000 has. The three largest NIS, which all have reservoirs in combination with run-of-the-river gravity irrigation systems, account for about one -third of total NIS service area (Inocencio, et al, 2018). The other two-thirds are mostly just run-of-the-river gravity irrigation, except for five medium sized NIS that pump water from large rivers (Inocencio et al. 2018).[1]

The large gap between actual irrigated area and design area in national irrigation systems have been pointed out in several studies and summarized in the policy-oriented World Bank irrigation sector review of 1992. Overly optimistic technical and economic assumptions, inadequate water supply, inappropriate designs of irrigation systems, difficulties in operation and maintenance have been listed as the main reasons for the disappointing performance of the national irrigation systems.

Upon examination of the NIS which started operation in the 1990s, they showed even poorer performance than irrigation projects completed earlier which should lead to question the budgetary allocations for those irrigation projects. There appears to be little effort to adopt more realistic assumptions in estimating design areas. Also, estimates of available water supply continue to be overstated and designs of irrigation systems have not adequately addressed or taken into account drainage problems, location-specific physical characteristics and rapid urbanization. Operation and maintenance have not significantly improved despite the nearing completion of irrigation management transfer to irrigators' associations.

The incentive structure to do more accurate ex-ante and ex-post evaluations of both new construction and rehabilitation irrigation projects (Table 1), more efficient engineering designs, and more effective operation and maintenance had been apparently too weak both within the bureaucracy and the lending agencies, despite presumably rigorous evaluations, particularly of foreign-funded projects.

Table 1. Appropriation for Irrigation per year

Year	Appropriation for irrigation (P billion)	Share in Department of Agriculture budget (%)
2011	12.79	36.8
2012	24.45	46.2
2013	27.16	42.1
2014	21.18	30.9
2015	26	42
2016	(no data)	(no data)
2017	38	(no data)
2018	41.7	(no data)

It should be emphasized that the opportunities to do better planning, construction, operation and maintenance, and rehabilitation are now much better. Greater and more accessible technical data have been collected through remote sensing and field level measurements. The technical capacity to undertake more modern and rigorous methodologies of analysis and design, e.g., GIS analysis, mathematical modeling and simulations, is now available in the country. However, the evaluation and continuous refinement of involvement of farmers in the governance of the sector from planning to rehabilitation remains relevant. The constraint appears to be the limited effective demand for improved governance of the sector.

[1] A few attempts have been made to introduce deepwell pumps in Central Luzon, but these have generally failed with the latest such project in Tarlac called the Tarlac Groundwater Reactivation Project also proving to be unsustainable.

Undoubtedly, the performance of irrigation systems is influenced not just by the quality of governance of the sector itself, but also importantly by factors outside its control. These are the worsening flooding problems caused by constriction of waterways; the rapid denudation of the watersheds which accelerate the rate of flooding and siltation within the irrigation system and reduce available water supply; and the political pressures impinging on the choice of irrigation projects and contractors, proper operations of irrigation systems, as well as quality of appointments in the bureaucracy.

NIS cases covered in this Report

The list of the 39 NIS cases in Luzon, Visayas and Mindanao is shown in Table 2. The selection of these NIS is based on criteria such as location, size, performance (successful/non-successful), and irrigation technology (gravity vs pump). For each selected NIS case, the proponents meet with the IMO Division Manager, NIS Manager, or any key personnel knowledgeable with the system. All available technical references including feasibility studies, technical drawings, and network maps were obtained (hard and soft copy). Review and analysis of the maps, including technical specifications, canal layout, location and functions of irrigation structures, and irrigated and built-up areas, were conducted. The 22 cases in Luzon (Figure 1) include 3 in Nueva Ecija, 3 in Tarlac, 1 in Pampanga, 1 in Bulacan, 2 in Ilocos Norte, 1 in Ilocos Sur, 2 in Pangasinan, 3 in Cagayan, 2 in Isabela, 1 in Camarines Sur, 1 in Occidental Mindoro, 1 in Quezon and 1 in Cavite. Specifically, the system names are PDRIS (Pampanga), TGIS and TASMORIS (Tarlac), UPRIIS (Nueva Ecija), AMRIS (Bulacan), Nueva Era RIS and Bonga Pump #2 PIS (Ilocos Norte), Banaoang PIS (Ilocos Sur), MARIIS (Isabela), Solana PIS (Cagayan), Visitacion RIS (Cagayan), Magapit PIS (Cagayan), Libmanan-Cabusao PIS (Camarines Sur), Ambayoan-Dipalo RIS (Pangasinan), Caguray RIS (Occidental Mindoro), Balayungan RIS (Cavite) and Dumacaa RIS (Quezon). Meanwhile, the 17 NIS cases in Visayas and Mindanao include 1 in Capiz, 3 in Iloilo, 3 in Bohol, 2 in Leyte, 3 in Bukidnon, 1 in Davao del Sur, 2 in North Cotabato, and 2 in South Cotabato (See Figure 2). Specifically, the system names are Mambusao RIS (Capiz), Jalaur-Suague RIS (Iloilo), Sibalom-Tigbauan RIS (Iloilo), Barotac Viejo RIS (Iloilo), Malinao RIS (Bohol), Capayas RIS (Bohol), Bayongan RIS (Bohol), Binahaan-Tibak RIS (Leyte), Daguitan-Guinarona-Marabong RIS (Leyte), Manupali RIS (Bukidnon), Pulangui RIS (Bukidnon), Roxas-Kuya RIS (Bukidnon), Padada RIS (Davao del Sur), M'lang RIS (North Cotabato), Maridagao RIS (North Cotabato), Marbel #1 RIS (South Cotabato), and Banga RIS (South Cotabato). All NIS covered were relatively old (more than 25 years) except for Pampanga Delta RIS, Malinao NIS and MalMar.

Figure 1. Relative locations of service areas of 22 NIS cases covered in Luzon.

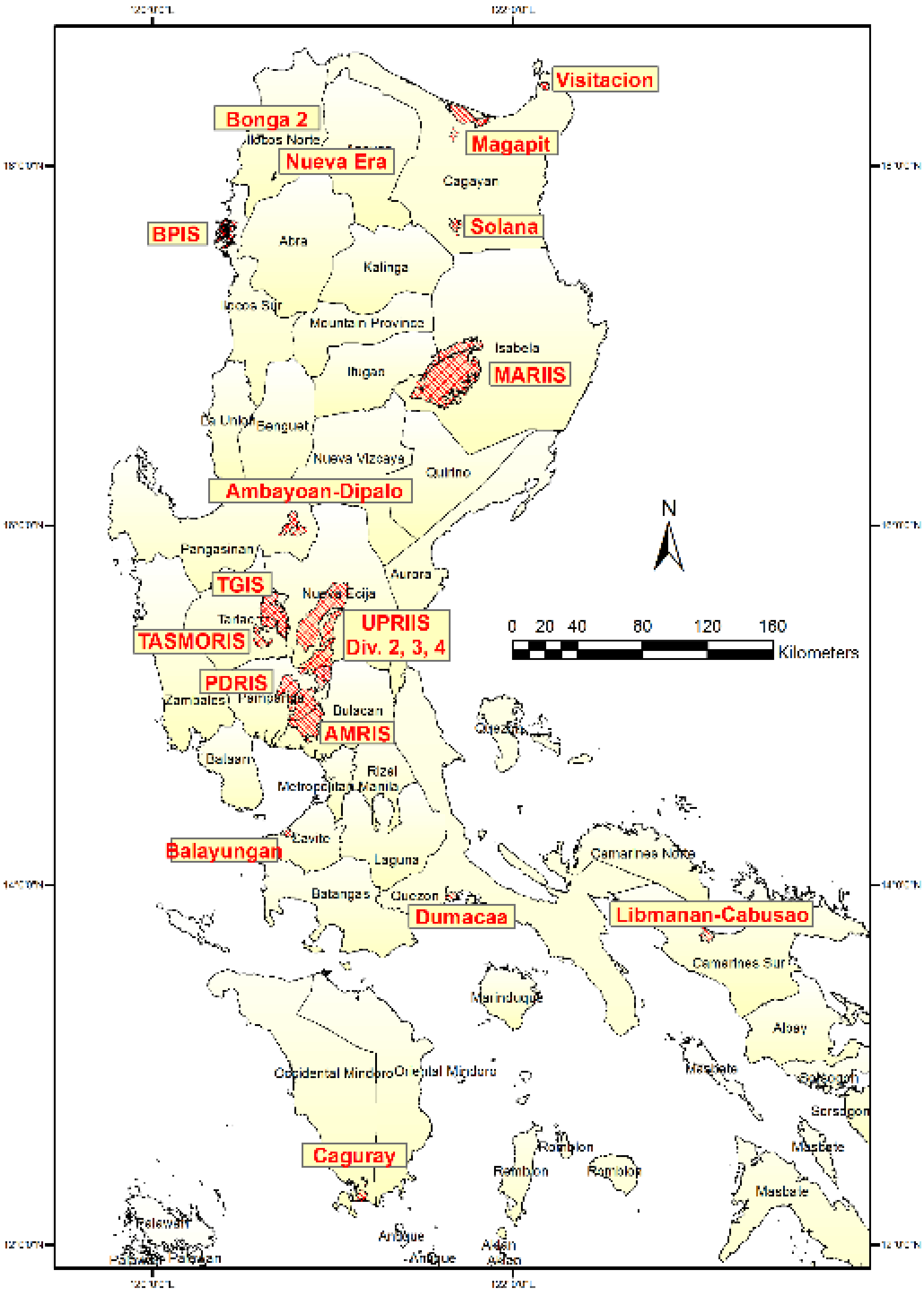


Figure 2. Relative locations of 17 NIS cases in Visayas and Mindanao.

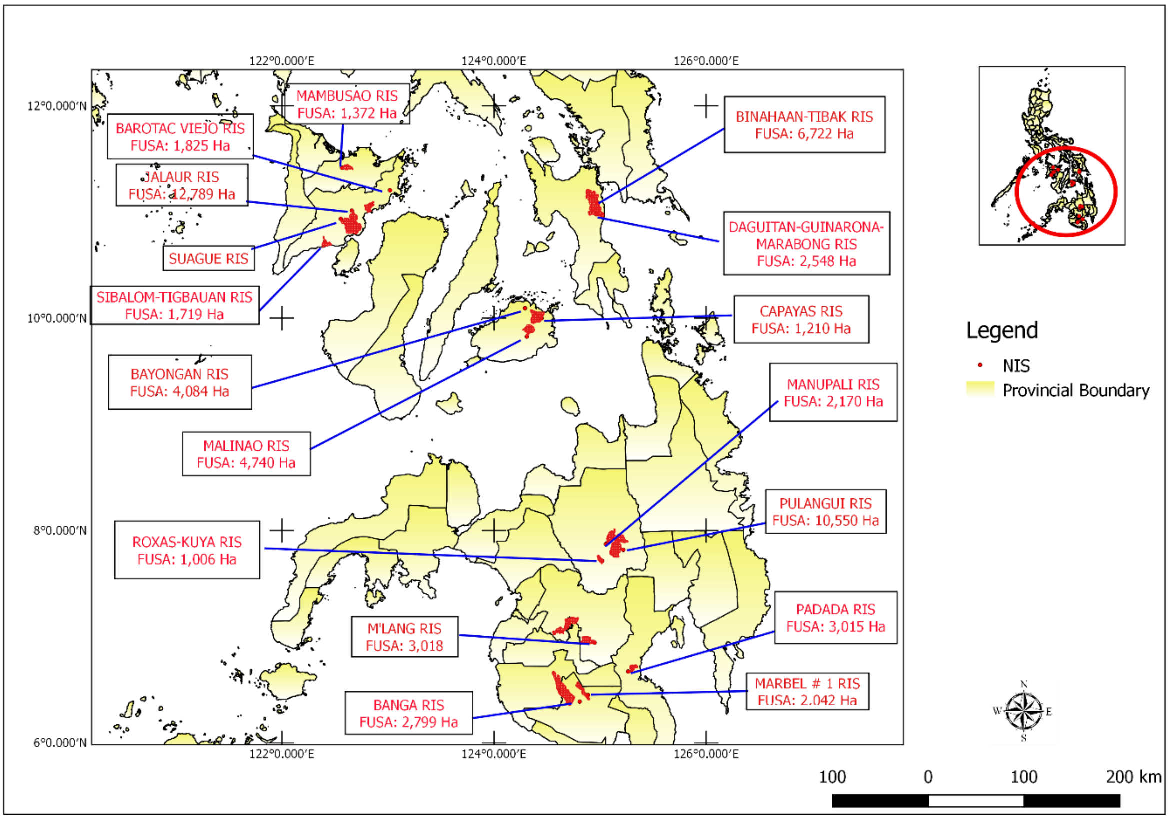


Table 2. List of NIS Cases covered in this Report

Count	Region	Province	System Name
2	1	Ilocos Norte	Nueva Era RIS and Bonga Pump #2 PIS
1	1	Ilocos Sur	Banaoang PIS
2	1	Pangasinan	Ambayoan RIS and Dipalo RIS
3	2	Cagayan	Magapit PIS, Solana PIS and Visitacion RIS
2	2	Isabela	Divisions 2 and 4 of MARIIS
3	3	Nueva Ecija	Divisions 2, 3 and 4 of UPRIIS
1	3	Pampanga	Pampanga Delta RIS
3	3	Tarlac	TGIS, Tarlac RIS and San Miguel-O'Donnell RIS
1	3	Bulacan	Angat-Maasim RIS
1	4B	Occidental Mindoro	Caguray RIS
1	4A	Cavite	Balayungan RIS
1	4A	Quezon	Dumacaa RIS
1	5	Camarines Sur	Libmanan-Cabusao PIS
1	6	Capiz	Mambusao RIS
3	6	Iloilo	Jalaur-Suague RIS

Count	Region	Province	System Name
		Iloilo	Sibalom-Tigbauan RIS
		Iloilo	Barotac Viejo RIS
3	7	Bohol	Malinao IS
			Bayongan IS
			Capayas IS
2	8	Leyte	Binahaan-Tibak RIS
			Daguitan-Guinarona-Marabong RIS
3	10	Bukidnon	Manupali RIS
			Pulangui RIS
			Roxas-Kuya RIS
1	11	Davao del Sur	Padada RIS
2	12	North Cotabato	M'lang RIS
			Maridagao RIS (MalMar 2)
2	12	South Cotabato	Marbel #1 RIS
			Banga RIS
39			**TOTAL**

2. Rationale and Objectives

The disappointing performance of public investments in large-scale irrigation in the Philippines has been documented as early as the late 1980's and early 1990's by David (1986), Ferguson (1987), and the World Bank (1992) mainly in terms of the significant gap between actual irrigated area and design area of selected national irrigation systems. Moreover, a Policy Note published by PIDS considered additional measures of performance of all NIS from the mid-1960s to 2012 which included cropping intensity and irrigation service fee (ISF) collection. However, it is recognized that there are other relevant indicators of irrigation performance of national irrigation systems. Thus, the overall objective of this component is to evaluate the policy, programmatic, and institutional framework governing irrigation development and management for the main purpose of improving irrigation performance and productivity of irrigated lands in the Philippines.

The Objectives for Component 1: National Irrigation Systems are as follows:
The project aims to evaluate the effectiveness, impact, and efficiency of the government's irrigation program. By component, the objectives are as follows:

Component 1: National Irrigation Systems

Objectives for this component are as follows:

(1) Characterize the distribution of all the NIS; examine the trends and patterns of performance indicators of NIS across the different systems, based on secondary sources.
(2) For selected **39** NIS cases, undertake the following:

Review the effectiveness of the NIS project cycle at each stage, namely identification, feasibility assessment, project selection, project design, construction, operation and maintenance, repairs, restoration, and rehabilitation;

Characterize and explain deviations, if any, from design area and intended water service delivery, based on technical evaluation, engineering measurements, GIS mapping, site visits (including walk-through), and key informant interviews especially of irrigators' association (IA) members;
Characterize and evaluate the incidence of individual pump usage within or in the vicinity of the selected NIS, in terms of effectiveness and cost, in relation to gravity irrigation users;
(3) Undertake an overall review of the effectiveness of the NIS project cycle based on Objectives (1) and (2) state recommendations to improve project identification, selection, design, implementation, operations, and maintenance.

3. Review of Literature

The fundamental causes of poor performance of government owned and managed irrigation systems in most cases are institutional rather than technical (Bottrall, 1995). The question is: what institutional arrangement would allow efficient and sustainable water management in irrigation? (Trung, et al, 2005).

Trung, et al (2005) compared the performance of three (3) irrigation management models to test if equity of water supply and land and water production are effective or not. The coefficient of variation and the modified water quality rate (MIR) as per Abernethy (1986) were used to estimate the equity in water distribution.

It was found that the increased participation of farmers in the decision-making process contribute to improved performance. For example, the equity of water distribution and land and water production are found higher in the model managed by the farmers, followed by shared management system and the conventionally managed.

Introduction of the large gravity irrigation system in the Indus Basin in the late 19^{th} century without a drainage system resulted in a rising water table, which resulted in water logging and salinity problems over large areas (Kazmi, et al, 2012). In order to cope with the salinity and water logging problems, the Pakistan government initiated installation of 10,000 tube wells in different areas. This not only resulted in the lowering of water table, but also supplemented irrigation. Resulting benefits from the irrigation opportunities motivated farmers to install private tube wells. The Punjab area meets 40% of its irrigation needs from groundwater abstraction (Kazmi, et al, 2012). Today, farmers apply both surface water flows and groundwater from tube wells, creating a pattern of private and public water control. The field work in the Lagar irrigated area, as discussed in this paper, shows that within the general picture of conjunctive use of canal water and groundwater, there is a clear spatial pattern between upstream and downstream areas, with upstream areas depending much less on groundwater than downstream areas. The irrigation context in the study area proves to be highly complex, with water users having differential access to canal and tube well water, resulting in different responses of farmers with their irrigation strategies, which in turn affect the salinity and water balances on the fields (Kazmi, et al, 2012).

Nowadays, with the Pakistan Government charging electricity at a flat rate when it is used for agricultural purposes, operational costs of electrically operated pumps are much less than that of diesel pumps (Kazmi, et al, 2012).

Tiewtoy, et al (2010) evaluated the performance of two projects in Thai Chin Basin namely Kangphaengsen (KPP) and Phrophraya (PPP) Irrigation projects based on key indicators using Principal Component Analysis (PCA). Results indicated that net farm income, awareness on irrigation water use, managing of water delivery schedule and agricultural operation and field application ratio are the major indicators of performance for KPP. In PP, on the other hand, analysis showed that irrigation sustainability is affected by 4 key indicators such as perception of drained water quality, satisfaction on adequacy of water distribution, field application ratio and net farm income.

Shah, et al (2016) examines the fairness in distribution of water in a tertiary canal within the Indus Basin Irrigation System. They have shown that although the depth of flow at the tail end of a canal is widely used in the Indus Basin Irrigation System as a proxy indicator, this is in fact a poor indicator of equity. They reaffirm that measuring flows within a canal where dedicated flow measurement structures do not exist and one has to resort to rating equations and/or measuring discharge through outlets still poses a challenge. However, it is still possible to obtain reasonable estimates and thereby determine the inequity in the system. The advantage of using a quantitative measure of inequity such as the Gini as opposed to the qualitative description hitherto more common is that it allows alternative comparisons to be made.

A study conducted by David, et al (2012) focused on the evaluation of National and Communal Irrigation Systems and Small Water Impounding Project (SWIP) in Ilocos Norte where irrigation intensity was used as an indicator of performance. It is aimed to examine the ratio of the actual irrigated area during the dry season to the irrigated service area. Results indicate that the performance of the system in the province are quite poor as reflected in the dry season cropping intensity of only 27% in 2005. This was partly attributed to the extensive damage of the dam covering the Madongan River Irrigation System which was also associated to the design shortcomings of the headworks and hydraulic structure.

Irrigation efficiency, as a complex and useful measure of irrigation performance, is in a vulnerable scientific position. Knowledge gaps feed through to naïve views of a sector held to be highly inefficient, ‘wasting’ freshwater which could be allocated to other purposes (Lankford, 2012).

The allure of irrigation efficiency as a single measure of system performance produces, in part, the doubts that irrigation scientists hold with it. Notionally simple, it is highly prone to capture by groups that engage with irrigation, feeding through variously to public and scientist/engineer understandings, and policies and practices regarding irrigation and water allocation. It can, without doubt, be misunderstood. Donors, advisers and irrigation engineers often ignore that irrigation systems sit nested within larger systems of recapture and reuse. Thus a ‘loss’ from one unit within the hierarchy should be parenthesised, qualified, and quantified (Lankford, 2012).

Raising irrigation efficiency can lead to increased consumption from the basin if the consumed fraction increases relative to the recovered fraction (Lankford, 2012).

As cited by Pradeep, et al (2015) and Mahato (2013), the following major reasons have been identified for low water use efficiency of irrigation projects in Maharashtra: poor or no-maintenance of canals/distributaries/minors of irrigation systems resulting in growth of weed & vegetation, siltation, damages in lining etc.; distortion of canal sections due to siltation or collapse of slopes resulting in some channels carrying much less and some other channels carrying much more than their design discharges; non-provision of lining in canal reaches passing through permeable soil strata; leakages in gates and shutters; damaged structures; no regulation gates on head regulators of minors causing uneven distribution of water; over irrigation due to non-availability of control structures and facilities for volumetric supply of irrigation water to farmers; poor management practices; lack of awareness among farmers about correct irrigation practices and cropping pattern.

The Jai Malhar Water user Association, Indore Minor Irrigation Project, Dist: Nasik, Maharashtra, India, discarded the use of open channel and established an innovative water conveyance and distribution PVC pipe system. This is to maximize the benefit and equitable distribution of water. They replaced the open channel water distribution network with innovative specially designed gravity flow PVC pipe water distribution network to resolve the above problems. On the other hand, their system has in-built effective and simple built-in) water management scheme (Pradeep, et al, 2015).

There is now a growing consensus among irrigation researchers that the primary reasons behind the poor performances of canal irrigation systems include: (1) inadequate data base for planning, (2) inadequate institutional capacity and mechanisms for project planning and development, (3) design errors, (4) poor quality of construction, (5) inadequate and fragmented irrigated agriculture support services, (6) overoptimistic assumptions of water use efficiency and irrigation service area during the project planning stage, and (7) failure to manage and distribute irrigation water efficiently and effectively (David, et al, 2012). Because of inadequate baseline information and institutional capacity for project planning, designers and builders of the irrigation facilities fail to establish appropriate design criteria (Horst 1998; Plusquellec 2002; David, 2003; 2008; 2009)

Horst (1998) concluded that often in the design phase, little to no attention is paid to operational aspects. He specifically identified the design of water division structures as the core of many irrigation problems. Owing to their functions, he argues that the type and characteristics of these structures largely determine the operability and manageability of the system and are the points of interface where conflicts of interest among farmers and between farmers and management often take place. He pointed out that the design of many water division structures was based on incorrect hydraulic supposition and was also devoid of social and institutional criteria such as staff requirement (in terms of number and skills), operability and social acceptance, among others. Such design shortcomings led to hydraulically unstable canals which were too cumbersome to operate, requiring extra field staff.

The problem of inappropriate design criteria has always been a major constraint to irrigation development in the Philippines. It can be traced to the failure to invest in the collection and the generation of the necessary baseline information and the limited interactions among design and O&M engineers. Design engineers are not required to test run the systems they designed in collaboration with those who are supposed to operate and maintain them. As a result, design errors are repeated from system to system without being rectified.

NIA irrigation systems in general appear to have various technical problems and issues that need to be resolved. First, it was observed that in the four selected irrigation systems (AMRIS, Pampanga Delta, Balog-Balog, and Casecnan) the actual irrigated areas had all been consistently below the target or design irrigation area (Tabios and David, 2014). The major reason was overestimation of irrigable areas by not fully accounting for built-up areas or urbanization, flooded areas during the wet season, and elevated areas that cannot be reached by gravity systems. Other reasons were mentioned such as overlapping watershed boundaries (e.g. Balog-Balog and Casecnan irrigation systems), competing water use in the case of AMRIS, and serious technical and financial issues concerning the proposed Balog-Balog dam.

A study was conducted by Moya (2014) for 14 irrigation systems in Luzon and Visayas to evaluate the kind of design problems determining underperformance of the systems. He reported several issues which caused low performance of the irrigation systems including, among others: a) field water requirements used in the design of most irrigation systems have been grossly underestimated; 2) water losses throughout the system were underestimated; and 3) on account of the conventional approach to designing canals and water control and regulating appurtenances based on maximum flow conditions, many irrigation systems are littered with redundant turnouts and unresponsive and long farm ditches that had increased project costs. Some recommendations to address these issues are also mentioned in the report by Moya (2014).

To obtain a good harvest, there is a need for adequate water supply and suitable quality. The main problem in the Philippine irrigation is the insufficient water supply. Most projects and rehabilitation work focus on providing structures for irrigation, neglecting the quality of the water irrigated on the crops.

The salinity of the water would be a problem if salt accumulates in the crop root zone to a certain level that would lead to loss in yield (Ayers and Westcot, 1994). Excessive salt in the rootzone would hinder the crops in extracting enough water from the soil. This could lead to slow growth and maturity of the crops that can significantly affect the yield.

Accumulation of toxic ions at sufficiently large concentrations also causes crop damage and reduced yields (Ayers and Westcot, 1994).

Some studies also link water quality and rice productivity. A study on the effect of water pollution on rice was conducted in Vietnam where rice farmers were surveyed in two areas with the assumptions of the same natural condition and social characteristics (Huynh and Yabe, 2012). One is considered as the polluted area near and directly receiving wastewater from industrial parks, while the other is assumed to be non-polluted area far from and having no effect of industrial pollutants. The yield loss of rice production caused by water pollution was estimated by the difference in rice yield between the two regions. The results showed that the yield loss of rice was about **0.57 – 0.75 tons per hectare per crop** (Huynh and Yabe, 2012). Polluted water hinders absorption of nutrients, and causes stunted growth of crops. Based from statistical analysis, there is also an increase in rice production cost and 26% profit loss due to water pollution.

Gao, et al (2017) used PCA to study the data structure of soil contaminations, relationships and differences of soil pollutions, and the major components of soil pollutions. The result of agriculture field quality classified with component scores showed that paddy field irrigated with clean water was on the top of the six types of land, and soil environment of sewage irrigated paddy field had the worst quality. The relationships with and contribution to contamination of soil pollutants were reflected well. The effect of heavy metals inputting was higher than organic pesticide, and is the major factor of soil contamination. The study implied that PCA is advantageous in the assessment on complex soil contamination and classification of soil environmental quality, and could be used in soil pollutants identification and soil environment assessment as well. The method could simplify the process of major soil pollutants identification especially in cases of complex or poorly recorded contamination.

A study by Wang, et al (2017) involved an experiment in a solar greenhouse spanning three consecutive growing seasons to evaluate the effects of irrigation and fertilization on the fruit yield and quality, water use efficiency (WUE) and fertilizer partial factor productivity (PFP) of tomatoes. Interactions between irrigation and fertilization treatments and individual factors of irrigation and fertilization significantly ($p < 0.01$) affected fruit yield, WUE and PFP. PCA results showed that WUE and fruit yield and quality were more sensitive to changes in irrigation than to changes in fertilizer, but PFP showed the opposite trend. Interestingly, the treatment with moderate irrigation (W2: 75% ET_0) and high fertilizer level (F1: $240N-120P_2O_5-150K_2O$ kg ha^{-1}) was twice ranked first after a combinational evaluation. It was concluded that proper application of drip fertigation (W2F1) may be a good compromise for solar greenhouse-grown tomatoes with regard to fruit yield and quality, WUE, and PFP.

Fang, et al (2017) studied the driving factors of irrigation water-use change based on a study of literature and a field survey. It selects 21 indices from five aspects of climatic change, resource endowment, economic situation, technological level, and management mode as the system of driving factors for irrigation water-use change. The statistical data on economic and social development in the 31 provinces of China in 2009 are analyzed using the principal component analysis (PCA) method to extract the main driving factors affecting irrigation water-use efficiency change. After calculation of factor scores, regional differences among driving factors of irrigation water use efficiency are evaluated and results show that these can be attributed to the factors of agricultural economic development, water-saving irrigation technology, water resource endowment, and dissipation.

Irrigation is firmly ensconced in key legislations for agriculture in the Philippines, namely Magna Carta of Small Farmers (RA 7607) and the Agriculture and Fisheries Modernization Act or AFMA (RA 8435). As such, it has commanded considerable investments from government, with significant surge over the last three years.

The Magna Carta requires that the government provide adequate support services that will address the development, management, and conservation of water resources (Section 19). The AFMA furthermore states the imperative to prevent the further destruction of watersheds, rehabilitate existing irrigation systems and promote the development of irrigation systems that are effective, affordable, appropriate, and efficient (Sect. 26). Irrigation development and management in the country has historically been the single biggest item of public expenditure for agriculture, accounting for about a third of the total budget since the 1960's (Inocencio et al. 2018). In the 1970s and early 1980s, as well as in recent years when world rice prices rose at unprecedented levels, this ratio averaged even higher, at close to half of total public expenditures for agriculture (Inocencio et al. 2018). In recent years, irrigation has taken up about 30–46 percent of the budget of the Department of Agriculture (Inocencio et al. 2018). In the 2015 proposed budget for the agriculture sector of PHP 62 billion, irrigation continued to get the biggest share of about PHP 26 billion or 42 percent of total.

4. Methodology

4.1. Field visits Arrangement with contacts at various IMOs and NIA offices of selected NIS and itinerary of activities.

Prior to field visits, Head of NIA offices (Regional Manager and Division Manager) in the NIS cases were contacted for scheduling of field visits and nature of activities. Request for secondary data were also coordinated. Secondary data include:

- NIS functionality surveys;
- Technical Data (i.e. system profile, service area, irrigation efficiency, construction cost, rehabilitation cost, yield, cropping calendar, cropping intensity, feasibility studies, technical drawings, layout map);
- Status of IAs (i.e. profile/institutional report of IAs, source of funding, financial status/viability, program of works (POWs) for all available years, and national irrigation system performance (NISPER).

4.2. Collection of data from primary sources (RAP: (KII FGDs), field measurements and observations) and secondary sources (NIA reports and documents)

The project activities include site visits, field measurements, and questionnaire surveys. Questionnaires for Key Informant Interviews (KII) and Focus Group Discussions (FGDs) for the 39 NIS cases were prepared and used during the field visits. These were part of Rapid Appraisal Procedure (RAP) of MASSCOTE where most of the questions are derived. KIIs of key system personnel (e.g. IMO, System managers, IDOs/operations staff, and IA President/officer) engaged in NIS operation were conducted. At the time of survey in Visayas and Mindanao, R.A. 10969 or Free Irrigation Service Act was being implemented. Some of the guide questions were revised to include the effect of Free Irrigation Service Act. NIA Memorandum Circular related to R.A. 10969 is summarized in Annex A. Detailed description of the guide questions and questionnaire surveys is presented in Annex B.

FGDs with IA officers/members were carried out. Information on socio-economic characteristics of farmer-members, institutional capacity of IA, problems and constraints in managing the NIS laterals, and of the IA itself was generated from the FGDs. The status and current conditions of the main canal and selected secondary and tertiary canals were initially determined through FGD. IA officers/members interviewed represented the upstream, midstream, and downstream section of each NIS cases.

Simultaneous with FGDs, walk-throughs and actual field measurements were conducted to determine the status and current conditions of the irrigation facilities. Measurements in the field were conducted using portable equipment (flow meters, water quality kits, etc.). Measurements include canal and structure dimensions, canal length, canal flow, silt depth, and water quality parameters (conductivity, DO and pH). Depending on the size of the IS, sections selected were: (a) near the dam or headgate (which represent the upstream), (b) in the middle (which represent the midstream), or (c) at the tail end of the system (which represent the downstream). These structures/facilities were photographed and geo-tagged (GPS readings) for proper referencing. Conveyance losses were measured on selected main and lateral canals, and where applicable, compared for lined and unlined canals.

Field activities and FGDs were conducted in the upstream, midstream, and downstream section because each location has customary and some unique characteristics. These characteristics may vary depending on the situations and should be verified by the field visits and FGDs. Example of customary characteristic is that upstream sections in a typical system have lined canals and complete structures. The upstream sections usually have high cropping intensity due to high reliability/availability of water. However, upstream sections usually have inactive farmers (as member of IA) and low payments of irrigation service fees (ISF). On the other hand, it could be expected that downstream sections in a typical system have unlined canals and incomplete structures (so water losses and inefficiency in water distribution are high compared to lined canals in the upstream part). In effect, the downstream sections usually have low cropping intensity due to low water supply. Downstream sections usually have active farmers (as member of IA) and ISF payments ranges from moderate to high. The condition at the midstream section could be in the range or the same as of the upstream and downstream sections. In terms of water quality, the downstream section is expected to have lower water quality. Therefore, evaluating the up-, mid- and downstream location could provide a better understanding of the overall condition of a specific irrigation system.

4.1.1. Technical/Physical Factors

The following is a partial list of primary and secondary data related to Physical/Technical factors collected in the different NIS:

- Location and description of project sites
- Climate (rainfall, temperature, humidity)
- Soil property (soil fertility)
- Irrigation water supply (flow ratio, field application ratio)
- Topography (DEM)
- Relative location of irrigated areas with respect to canal network
- Location of Sub-Main Canal in the field
- Relative position of irrigated area to water resource
- Irrigation and drainage ditch condition and siltation

These factors address the degree of satisfaction of farmers on the condition of ditch (canal) and drainage ditch system in terms of cleanliness and smoothness. These also reflects the erosion/siltation problem in the canals which can be related to flow capacities. Degree of satisfaction is classified into five levels, i.e. 1=strongly dissatisfied, 2=dissatisfied, 3=neutral, 4=satisfied, 5=strongly satisfied.

4.1.2. Institutional Factors

The questionnaires were used to determine the farmer's degree of satisfaction on irrigation water delivery. Details such as the degree of satisfaction on the adequacy of water distribution to individual farms, matching of farm operations with NIA water delivery, reliability of continuous flow during irrigation period, degree of satisfaction on institutional organization, and information about the farmer's willingness to pay for their irrigation water are also included in the questionnaires. A five-point Likert scale was used for optimization. Each item in this scale ranged from 1 (strongly disagree) to 5 (strongly agree). The reliability of questionnaires was tested using Cronbach's alpha coefficient method (Pallant, 2005).

4.1.3. Environmental Factors (Water quality)

The important environmental factors to consider in irrigation water quality are electrical conductivity (EC), total dissolved solids (TDS), pH and dissolved oxygen (DO).

Electrical conductivity (EC)

Electrical Conductivity (EC) is a measure of the water salinity or the total salt content of water based on the flow of electrical current through the sample. EC is measured in unit deciSiemens per meter (dS/m).

Total dissolved solid (TDS)

Total dissolved solid (TDS) represents the total amount of salts in the water. It is reported in milligrams per liter (mg/l), parts per million (ppm) or parts per thousand (ppt). The TDS concentration can be obtained by multiplying the conductivity value with a factor which is empirically determined.

Acidity/Alkalinity (pH)

pH is a measure of the acidity or alkalinity of water. The pH scale ranges from 1 to 14; water is acidic if pH is between 1 to 7, whereas alkaline for the range between 7 to 14. Water is neutral at pH 7.0. The normal range for irrigation water is from pH 6.5 to 8.0 where crops have done well in this range. Table 3 presents the classification of water quality in different scores for each quality level using guidelines of Arnold, et al (2007) for interpretation of irrigation water quality.

Table 3. Classification of Water Quality for Irrigation Water.

Electrical Conductivity (EC) (dS/m)	TDS (ppm)	pH	Quality	Score
< 0.25	<175	<6.5	Excellent	5
0.25-0.75	175-525	6.5-6.8	Good	4
0.75-2.00	525-1400	6.8-7.0	Permission	3
2.00-3.00	1400-2100	7.0-8.0	Doubtful	2
>3.00	>2100	>8.0	Unsuitable	1

Source: Arnold, et al (2007)

Dissolved oxygen (DO)

Dissolved Oxygen (DO) indicates the amount of oxygen dissolved in a body of water. In this study, DO will be classified into four classes such as: a much deteriorated, deteriorated, fair, and good. Table 3 presents the classification of dissolved oxygen (DO) using the guidelines of Pollution Control Department (PCD, 2007) to interpret the DO factor and assign a score for each quality level presented in Table 4.

Irrigation water quality data were analysed at the project sites using portable water quality kits at three locations i.e. upper, middle, and lower sections of each main canal. The water quality parameters analysed include i.e. pH, electric conductivity (EC), total dissolved solid (TDS), and dissolved oxygen (DO).

Table 4. Classification of Dissolved Oxygen (DO) Quality.

(Dissolved Oxygen) (mg/l)	Quality	Score
<2	Very deteriorated	1
2-4	Deteriorated	2
4-6	Fair	3
>6	Good	4

Source: PCD, 2007

4.3. GIS mapping and Spatial Analysis

Available maps especially service area maps from each NIS cases were digitized if no shapefiles were available. Walkthrough maps of specific NIS cases covered were developed using the service area map and GPS readings of headworks, canal structures and water flow and quality measurement points. Moreover, available digital elevation maps (DEM), soil erosion maps, soils maps, built-up area maps, and ground water potential maps were presented for specific NIS cases. Data for these maps were obtained/ sourced from Department of Agriculture, DA-BAR, DA-BSWM, NWRB, NAMRIA, DA-CIRDUP, and Google Maps.

Spatial analysis is done by generating hillshade effect on the DEMs acquired through remotely sensed images from ASTER. After which, the erosion map is shown side by side with the DEM with delineated watershed in order to have a visual explanation as to where the possible siltation came from (which could be due to the process of erosion and sedimentation from the upstream down to the downstream portion of the watershed and accumulation in the entry point or pour point region of the watershed. The rampant and prevalent problem among all NIS is the siltation problem. With this, it is necessary to generate/delineate the watershed that may be the source of siltation on the particular service area/s of the visited NIS. Delineating the watershed that may possibly be one of the sources of siltation is done using spatial analysis in ArcGIS.

Service area maps and groundwater potential maps were overlaid to show/present areas within a specific NIS cases with potential for STW irrigation. Potential STW irrigation areas could supplement NIS during low water supply.

In addition, Coastal Flood modelling is also done especially in the Magapit PIS in order to show the seawater intrusion experienced by some farmers near the coastal region of the NIS. Moreover, overlaying the slope, soil type, erodibility, and built-up areas are done in order to show the reason why there is reduction in service area and occurrence of siltation problems in most NIS canal systems.

4.4. Irrigation Performance Assessment using Principal Component Analysis (PCA)

In this study, principal component analysis (PCA) may help in identifying the factors presenting the most important variability in the sample, and then, explaining most part of the total variability which represent technical, socio-economic, institutional and environmental parameters that affect irrigation performance.

The three main steps in PCA approach are as follows:

Step 1 – Is the assessment of the suitability of the data. A statistical measure was generated by Stata to help assess the validity of the PCA factor determinants called Kaiser Mayer Olkin (KMO) measure of sampling adequacy (Kaiser, 1974). The KMO is expected to be greater than 0.5 to consider the PCA model to be a recommendable and acceptable value. Furthermore, KMO values between 0.5 - 0.7 are claimed to be mediocre, 0.7 – 0.8 are good, 0.8-0.9 are great, and finally, values above 0.9 are superb (Field, 2005). To inspect the validity of the variables to be part of the principal components, a correlation matrix for evidence of coefficients were generated. Variables with correlation coefficients greater than 0.3 are found to be appropriate (Pallant, 2005).

Step 2 – Is factor extraction using PCA approach. Tabachnick and Fidell (2000) recommend Kaiser's criterion techniques to assist in the decision concerning the number of factors to be retained. Factors with an eigenvalue of 1.0 or more are retained for further investigation.

Step 3 – Is factor rotation and interpretation. The most commonly used orthogonal approach is the varimax method (Kaiser, 1958) which attempts to minimize the number of variables that have high loadings on each factor. Although the acceptable varimax index is greater than 0.3, the study used a cut-off of 0.4 to increase the validity of the weight of the variable index.

Determination of dominant factors affecting irrigation system

The analysis involved a sequence of logical steps, starting with the initial selection of factors to the determination of key factors that best represented the technical, socio-economic, institutional, and environmental parameters. To complete the PCA the following steps are performed:

1. Selection of a set of technical, socio-economic, institutional and environmental factors for the study area.
2. T-test was used to test normality of data distribution and Cronbach's alpha was used to test the reliability of questionnaire. Moreover, bivariate analysis was used to test the correlation of data.
3. PCA was used to find out the principal components (PCs) as the best representative factors or indicators (key factors). It will be assumed that PCs with high variance (eigenvalues) best represent system indicators. Therefore, only PCs with eigenvalues more than 1 are used for further analysis (Pallant, 2005). Eigenvalues are the amount of variance explained by each factor, in this case "technical, socio-economic, institutional and environmental indicators/attributes".

Then the irrigation performance index (IPI) is developed based on principal components (PCs) that are defined as linear combinations of the variables that account for maximum variance within the data set. IPI is formulated using the score of key indicators which are obtained earlier by PCA.

It should be noted that IPI is developed to reflect the technical and Institutional effectiveness of the project cycle from project identification, feasibility up to O&M since the factors and questions related to these stages of the project are captured in the PCA. Moreover, the IPI will indicate more than just Technical and Institutional dimension of irrigation management because it also includes Socio-economic and Environmental indicators that affect irrigation systems performance and effectiveness. That is why our irrigation evaluation approach will be more comprehensive and encompassing since it covers both the effectiveness and overall performance of the systems based on 4 these major indicators.

5. Results and Discussions based on Primary and Secondary Data

5.1. Synthesis of Key Observations/Findings for the 39 NIS covered

The major issue under Technical/Physical is siltation problems. The source of siltation is the rivers that supply water for the irrigation systems. Excessive river siltation causes lower water intake and canal siltation. Canal siltation causes reduced flow capacities that deprive the downstream section of adequate water supply. Excessive siltation of the dam as well canal siltation was observed in Ambayoan-Dipalo RIS (see Annex C and Photo 1), Nueva Era RIS, TASMORIS, Caguray RIS, Jalaur-Suague RIS, Padada RIS (see Photo 2), M'lang RIS and Manupali RIS (see Annex C). Poor watershed management results in upland erosion and siltation of the rivers. This was partially verified by the erosion maps generated through GIS (see Annex C). Watershed management and environmental studies are important consideration in engineering design and feasibility study of irrigation projects. The degradation of the watershed due to human activities and other factors is deemed to be one of the reasons for the unstable water resource for irrigation. Although watershed management is being considered during design stage, it has problems during operation of the system after construction. In the Philippines, administratively, watersheds were being managed and controlled by the DENR not by NIA in the case of NIS watershed. To reduce future rehabilitation works due to desilting, provision of silt control devices, either on the head works or on main or lateral canals, should be included in the design, especially for sediment laden rivers or creeks. Moreover, sediment discharge studies should be considered as a prerequisite in the feasibility study. Estimation of sediment discharge should also be included in standard river flow measurement, in light of the escalating erosion of our watersheds.

As part of the design, siltation of the dam can be controlled by opening the sluice gates during high river flow. But opening the sluice gates can only control siltation at a certain extent. On the other hand, canal siltation can be controlled by regular maintenance. Silt control in silted canals can be implemented through dredging or through the use of structures (i.e silt ejector of PDRIS and Marbel #1 RIS – in Annex C, by-pass canals). The lack of canal maintenance was mentioned during FGDs (as reason for canal siltation) by Mapamasa IA in Division 4 of UPRIIS, Muhara IA in Solana PIS, Zigiran IA in Magapit PIS, Carsan IA in Ambayoan-Dipalo RIS, and Gamot Bolo Nicolas IA in Caguray RIS, among others. Siltation depth was measured in PDRIS (see Annex C) and was found to range from 6 cm midstream to 37 cm downstream. This indicates that flows have reduced considerably from the upper to lower sections of the main canal which is consistent with the increase in siltation depth from midstream to downstream.

Photo 1. Silted diversion dam of Dipalo RIS

Photo 2. Silted Main Canal of Padada RIS where presence of shellfish is evident.

Siltation is also part of the headwork problems of all pump irrigation system (PIS) covered (Bonga Pump #2, Banaoang, Libmanan-Cabusao, Solana and Magapit). Siltation could not be minimized in these systems since all of them were drawing water from major rivers (i.e. Cagayan River for Solana and Magapit PIS and Libmanan River for Libmanan-Cabusao PIS; see also Annex C). These major rivers were not just outlets of water but also outlets for sediments.

The next major issue observed in the NIS cases covered was canal lining. The efficiency of water distribution is a function of the condition of the main canals and laterals in terms of the lining coverage. If canal linings were not completed, the assumptions during design stage will not be valid. This could be one of the reasons for the large discrepancy between the design service area and actual irrigated area or the discrepancy between FUSA and actual irrigated area. For example, the canal efficiencies for Divisions 1, 2, 3 and 4 in MARIIS (Table 5), and Divisions 1, 2 and 5 in UPRIIS (Table 6) ranged from 41.3 to 81 % and from 49 to 73.8%, respectively. The design conveyance efficiency in main canals is 90% while in laterals is 80%. This validates again the findings that earth canals have more seepage and percolation losses compared to lined canals hence efficiency in lined canals are higher than earth canals. More than 80% of the main canals and laterals in PDRIS, Bonga Pump #2, Libmanan-Cabusao PIS, Malinao IS, Capayas IS, Bayongan IS, Manupali RIS, and Marbel #1 RIS are lined (Table 7 and 8). In contrast, more than 80% of the main canals and laterals in AMRIS, Magapit PIS, Jalaur-Suague RIS, Barotac Viejo RIS, and Mambusao RIS are unlined or earth canals (Table 8 and 9). In addition, animals (especially carabaos) are frequenting the earth canals, causing damage (see sample in Photo 3) and collapse of the canal side slopes which can result in more serious problems.

Photo 3. Damaged canal end section of Lateral D2-D2, Div. 4, MARIIS. Pile of sediments could be observed in both embankments of the canal

Table 5. MARIIS canal efficiency summary

DIVISION	CANAL	LENGTH (m)	LOSS			Stretch Efficiency (%)	Total Stretch Length (m)	Total Loss (cu.m./s)	Measured Efficiency* (%)
			cu. m/s	lps	lps/km				
I	Lateral Q	525.0	0.0486	48.6477	92.662	96.5	1448.0	0.2672	81.0
		602.0	0.1676	167.5854	278.381	87.2			
		321.0	0.0510	50.9650	158.769	95.4			

DIVISION	CANAL	LENGTH (m)	LOSS			Stretch Efficiency (%)	Total Stretch Length (m)	Total Loss (cu.m./s)	Measured Efficiency* (%)
			cu. m/s	lps	lps/km				
	South Flow Main	43.0 484.0	0.1085 0.4667	108.4520 466.6560	2522.134 964.164	88.9 58.0	527.0	0.5751	41.3
II	Lateral A5	237.0 390.0	1.1583 0.4964	1158.3210 496.4220	4887.430 1272.876	74.4 75.1	627.0	1.6547	63.4
	Lateral B	317.0 633.0	0.6232 0.6394	623.2140 639.4420	1965.975 1010.176	86.7 84.9	950.0	1.2627	73.0
III	Lateral A	374.0 202.0 474.0	0.1731 0.0605 0.0424	173.0480 60.4780 42.4410	462.695 299.394 89.537	77.5 89.4 89.0	1050.0	0.2760	64.2
	NDC 9	243.0 400.0 216.0 257.0	0.2316 0.0967 0.1038 0.0728	231.5670 96.6570 103.7970 72.8040	952.951 241.643 480.540 283.285	80.9 89.3 86.0 88.4	1116.0	0.5048	58.4
IV	Lateral A1	532.0 168.0 194.0	0.4390 0.1523 0.0626	439.0180 152.3130 62.6350	825.221 906.625 322.863	69.1 71.8 86.9	894.0	0.6540	54.0
	Lateral A1A	272.0 225.0	0.1595 0.0159	159.4680 159.2040	586.279 707.574	79.4 74.1	497.0	0.1754	77.3

Source: DOST NUWAM Project

Table 6. UPRIIS canal efficiency summary

DIVISION	CANAL	LENGTH (m)	LOSS			Stretch Efficiency (%)	Total Stretch Length (m)	Total Loss (cu.m./s)	Measured Efficiency* (%)
			cu. m/s	lps	lps/km				
I	Lateral F1-A	185.0	0.1550	155.0305	0.838	85.4	620.6	0.2783	73.8
		120.8	0.0304	30.4115	0.252	97.2			
		134.9	0.0494	49.3712	0.366	94.7			
		110.9	0.0056	5.5842	0.050	98.2			
		69.0	0.0379	37.9289	0.550	70.4			
II	Lateral C1	1000.1	1.0156	1015.5710	1015.480	78.8	1552.1	1.3811	71.1
		552.0	0.3656	365.5660	662.257	89.8			
V	Lateral E1	247.1	0.2719	271.8680	1100.233	69.3	548.1	0.4516	49.0
		110.0	0.0164	16.3980	149.074	97.4			
		111.0	0.1527	152.6620	1375.333	76.6			
		80.0	0.0106	10.6340	132.923	98.1			

Source: DOST NUWAM Project

Table 7. Summary of lined canals per system

Name of System	Location/Municipality	LINED CANAL (km.)			(%)
		MC	LAT	TOTAL	
PDRIS	Arayat, Pampanga	31.8	29.8	61.6	89.12
AMRIS	Bulacan, Pampanga	23.751	32.804	56.555	15.37
NUEVA ERA RIS	Nueva Era locos Norte	4.498	0.52	5.018	40.44
BONGA PUMP #2 RIS	San Nicolas, Ilocos Norte	14.133	14.529	28.662	95.03
MAGAPIT PIS	Camalaniugan, Cagayan	17.53	-	17.53	13.55
LIBMANAN-CABUSAO PIS	Camarines Sur	7.516	34.5223	42.0383	85.12
VISITACION RIS	Sta. Ana, Cagayan	3.938	6.757	10.695	42.57
CAGURAY RIS	Magsaysay, Occidental Mindoro	13.52	11.33	24.85	58.66

BALAYUNGAN RIS	Naic, Maragondon Cavite	7.591	13.65	21.241	43.40
DUMACAA RIS	Lucena City, Quezon	1.12	36.172	37.292	46.66
					52.99

Table 8. Summary of unlined canals per system

Name of System	Location/Municipality	UNLINED CANAL (km.)			(%)
		MC	LAT	TOTAL	
PDRIS	Arayat, Pampanga	0	7.52	7.52	10.88
AMRIS	Bulacan	92.153	219.206	311.359	84.63
NUEVA ERA RIS	Ilocos Norte	-	7.392	7.392	59.56
BONGA PUMP #2 RIS	Ilocos Norte	-	1.5	1.5	4.97
MAGAPIT PIS	Camalaniugan, Cagayan	11.24	100.567	111.807	86.45
LIBMANAN/CABUSAO PIS	Camarines Sur	0.456	6.891	7.347	14.88
VISITACION RIS	Sta. Ana, Cagayan	6.842	7.586	14.428	57.43
CAGURAY RIS	Magsaysay, Occidental Mindoro	2.36	15.15	17.51	41.34
BALAYUNGAN RIS	Naic, Maragondon Cavite	6.485	21.2198	27.7048	56.60
DUMACAA RIS	Lucena City, Quezon	2.582	40.049	42.631	53.34
					47.01

Table 9. Summary of lined, unlined and FUSA of the NIS in Mindanao (being consolidated to include Luzon and Visayas)

	Lined (%)		**Unlined (%)**		**FUSA**
	Main	Lateral	Main	Lateral	
MAMBUSAO RIS	29.83	19.19	70.17	80.81	1372
JALAUR-SUAGE RIS	5.69	7.48	94.31	92.52	12789.72
SIBALOM-TIGBAUAN RIS	37.92	1.57	62.08	98.43	1719.00
BAROTAC VIEJO RIS	2.87	11.36	97.13	88.64	1700.28
MALINAO IS	100.00	100.00	0.00	0.00	4740.00
CAPAYAS IS	100.00	100.00	0.00	0.00	1113.10
BAYONGAN IS	100.00	100.00	0.00	0.00	4084.00
BINAHAAN-TIBAK RIS	35.78		64.22		6444.00
DAGUITAN-GUINARONA-MARABONG RIS	89.57	66.13	10.43	89.57	2615.00
MANUPALI RIS	100.00	100.00	0.00	0.00	2170.00
PULANGUI RIS	57.36	33.74	42.64	66.26	10557.00
ROXAS-KUYA RIS	59.28	46.59	40.72	53.41	1006.00
PADADA RIS	30.50		69.50		3015.00
M'LANG RIS	23.51		76.49		3017.59
MALMAR2	32.44		67.56		19601.00
MARBEL #1 RIS	100.00	100.00	0.00	0.00	2042.78
BANGA RIS	80.83		19.17		2805.00

Another major issue observed in the NIS cases covered was non-functional, missing, or damaged irrigation structures. Irrigation structures are for measurement, control, and distribution of irrigation water supply. Staff gauges (part of flow-measuring structure) are lacking or missing in most NIS cases visited (e.g. Libmanan-Cabusao PIS, Ambayoan-Dipalo RIS, Caguray RIS, Balayungan RIS, BPIS, Bonga Pump #2 PIS, Nueva Era RIS, and TGIS) which limits information on available flows; and canals/structures (see sample in Photos 4 to 6) are damaged which affects water delivery service (e.g. Victoria IA in MARIIS, MalMar 2, and Manupali RIS). On the other hand, the rehabilitation and installation of staff gauges is on-going during the time of visit (June to August, 2018) in the NIS cases in Visayas and Mindanao.

Lack of information on canal flows poses a concern on the operational efficiency of the system since flows should be monitored to ensure that water delivered corresponds to what is required. In effect, the delivery performance ratio, an indicator which describes the actual over design discharge cannot be assessed yet but needs to be determined to show the water delivery efficiency of the systems. In measurements conducted in AMRIS (see Annex E for details), where main canal is supplied by the Ambuspa Pump, discharge was found to be 0.45 m^3/s and at the downstream portion (lateral B Station 4 + 120), the discharge was estimated to be 0.31 m^3/s. It can be seen that the flow from the main canal was reduced when diverted to the lateral. Because rotation is practiced along the lateral, which results in the diversion of water from the main canal to a number of laterals, there is a reduction in flow. Furthermore, equal distribution of water could not be achieved if irrigation structures were missing or damaged.

During design stage, system performance considered was based from the design standards that all canals were lined, and canal structures were in placed. However, after construction, most of the NIS in the country were actually completed if compared to the original design. Most of the deviations were unlined canal and reduced area covered. Thus, it will result in the deviation between designed service area and actual irrigated area. Moreover, there were no interactions between design and O&M engineers of irrigation system (David, 2004). Problems related to design during operations were not properly conveyed to the designers. This is evident of the problems encountered by the NIS designed in the 1970s and designed in the early 2000s encountered the same operational problems as canal seepage, siltation and lack of structures.

Photo 4. Control and division structures along Lateral B, Div. 2, MARIIS

Photo 5. Missing gates in MalMar 2 RIS.

Photo 6. Damaged headgates control lever of Lateral A of Manupali RIS.

Flooding problems also exist in most NIS (e.g. PDRIS, Magapit PIS, AMRIS, M'lang RIS, MalMar 2, and Pulangui RIS) especially during wet season which limit cropping to dry season only and thus reduce the Cropping Intensity of the said NIS (see Annex C). Furthermore, drainage canals are lower than the river (e.g. Lal-lo IA in Magapit and TG 86 in TGIS) so flooding problems exist especially during wet season since drainage canals cannot drain out the excess water.

Not only the NIS cases covered but also other gravity irrigation systems in the country are experiencing lack of irrigation water supply. Lack of water supply could be presented in the point of view of NIA and in the point of view of IAs and farmers. But both acknowledged that lack of water supply is due to declining water intake from denuded watersheds of the irrigation systems. The lack of water supply could be easily observed with difference between FUSA and actual irrigated area, especially during dry season. To close the gap, IMOs in some NIS were maximizing available water resources in the service areas. Example of these are construction of re-use dam (see Photos 7 and 8), construction of intake dam, installation of open source pumps (re-pump), and installation of shallow tubewells (STW). Re-use dams could be observed in UPRIIS, MARIIS, Balayungan RIS, Dumacaa RIS, Binahaan-Tibak RIS, Daguitan-Guinarona-Marabong RIS, Jalaur-Suague RIS, Barotac Viejo RIS, Padada RIS, M'lang RIS, Marbel #1 RIS, Banga RIS, and Pulangui RIS (see Annex C). Magapit PIS, PDRIS, UPRIIS and MARIIS (see Annex C) have re-pump stations.

There is a need to reevaluate the definition of potential irrigable areas, including the assessment of water supply sources and comprehensive land use plans of the local government units. In estimating potential irrigable areas, improved data collection and management is necessary. In all the feasibility studies of all the NIS in the country, data adequacy and quality are always the constraints to proper estimation of irrigable areas. Although soil texture and land suitability to certain type of crops were being considered during design, reliable data in the field were however not collected. Science-based information hydrologic data should include smaller rivers and creeks. Water supply and water demand projections using new climate change scenarios can be useful in identifying new and potential sites for irrigation development. Groundwater potential should be assessed by estimating recharge rates via water balance but needs complete data sets on inflow outflow parameters.

Photo 7. Vaca Dam of Division 2, UPRIIS

Photo 8. Belisong #1 dam (re-use dam) of Lower Binahaan RIS.

On the other hand, in the point of view of IAs and farmers, the irrigation system should supply the required irrigation for the duration of the cropping. The lack of water supply would mean using supplemental modes of irrigation. The most common supplemental mode of irrigation is pumping. Sources of water for pumping are irrigation and drainage canals, tubewells, lakes, and nearby creeks and streams. Pumping from irrigation and drainage canals could be observed in BPIS, Solana and Magapit PIS (see Photo 9), UPRIIS, MARIIS, Libmanan-Cabusao PIS, Malinao IS, Binahaan-Tibak RIS, Sibalom-Tigbauan RIS (see Photo 10), Padada RIS, MalMar 2, and M'lang RIS (see Annex C for other systems). Although only a few STW were observed during the walk-throughs (see Photos 11 and 12), FGDs showed that STWs were being used in some NIS cases. Based from groundwater potential maps in Annex C, service areas of PDRIS, BPIS, Bonga Pump #2 PIS, TASMORIS, some areas of UPRIIS and MARIIS, and Solana and Magapit PIS, Binahaan-Tibak RIS, Jalaur-Suague RIS, Barotac Viejo RIS, Padada RIS, M'lang RIS, and Pulangui RIS are within shallow well potential areas. During dry season or periods of prolonged water shortage, alternate wetting and drying (AWD) approach is being practiced in most of the irrigation systems covered. This is an example of deficit irrigation (DI) where water delivery is reduced to a level lower than discharge capacity or design discharge. However, to be effective, DI should be practiced in such a way that the reduction in water delivery should not be lower than what is required by the crops to obtain optimum production. To achieve this, the concept of DI should be applied at different growth stages of crop growth which correspond to different levels of water requirement. If this is adopted properly then optimum production and profit can be achieved.

Photo 9. A pump set extracting water from drainage canals in Magapit PIS

Photo 10. A pumpset installed along Main Canal, Sibalom-Tigbauan RIS (downstream section).

Photo 11. A pumpset installed in the service area of Jalaur RIS (downstream section).

Photo 12. A pumpset installed in the service area of Padada RIS.

Lack of policy or its weak implementation on illegal settlers (e.g. Camalap IA in Magapit PIS), dumping of garbage, and illegal pumping have caused both delivery and environmental issues. In Div. 3 of UPRIIS, informal settlers along the canals pose solid waste problems. Garbage was observed in a section of lateral in AMRIS (Photo 13) and Pulangui RIS (Photo 14). According to different IMO, different Resolutions were issued by LGUs concerned regarding waste disposal in the canals but to no avail. Other issues include poor water delivery scheduling and distribution (e.g. TGIS, Kadaklan Baldias IA in Nueva Era RIS, Cabusligan IA in BPIS, New Life IA in Division 2 of MARIIS, and Kaps Ambayoan IA in Ambayoan RIS) and conflicts among users especially when upstream members block the path of water which reduces the water supply for the downstream part. Illegal pumps also exist in some laterals (see

Photo 15) plus illegal diversion of water through KKB ("kanya kanyang butas") along the canals (see Photo 16). It is however difficult to track down the violators since the improvised holes are not visible when water is flowing deep.

There is inconsistent policy implementation on pumping irrigation water. In Luzon, pumping is strictly illegal in NIS service areas while some systems in Visayas and Mindanao allow pumping within the service areas. Malinao IS and M'lang RIS allow pumping at certain schedules because the farm elevation is higher than the canal elevation.

Coordination between agencies will always be a problem but needs to be enhanced via a government program on integration and collaboration among related agencies. Specific laws or regulations are always needed for a certain agency to fully coordinate with another one. For now, a Memorandum of Agreement specifying the roles and responsibilities of each agency and mechanics for coordination may be useful.

Photo 13. Garbage in gates of one section of Lateral B NMC, AMRIS

Photo 14. Section of South Main Canal of Pulangui RIS with floating debris trapped in a headgate.

Photo 15. Illegal pumping unit along MC of LTRIS, Division 2, UPRIIS

Photo 16. Illegal turn out along lateral of Caguray RIS
(Photo courtesy of Engr. Wilson Lopez)

Farmers are also resistant to change and new technology adoption and some are hesitant to pay ISF because of poor water service especially in the downstream part. In Bohol, Leyte and Iloilo, most IAs respondents have expressed satisfaction for the Free Irrigation structure especially the farmers because they no longer have to pay the fees. In effect they can use the savings for other purposes. As members of the association, however, there are some minor fees that the farmers have to pay such as management and association fees. For the IAs, they also have some incentives representing remuneration and canal clearing. But the IAs response in Jalaur, Iloilo seems to be different from the rest of the NIS in Visayas since some IAs are not quite satisfied with the new policy of free irrigation. This is because even the main canal from the source has shortage of water due to siltation problem which is not being addressed due to lack of funds and support from NIA. This is also true in Mambusao RIS where some IAs are complaining that laterals (e.g. Lateral C) are only partially operational and some canals are lower than the field so small check dams are built, which usually overflow.

For the governance of NIS, IAs have varying response with regard to the impact of free irrigation. Although the IAs receive some incentives in lieu of ISF (e.g. management and association fees), some IAs complain that the incentives cannot fully cover the maintenance costs, especially those involving major repairs or rehabilitation. The O&M compensation of PhP150 per hectare and canal clearing support of PhP250 pesos per km (lined) and PhP500 pesos per km (unlined) are not enough especially for Mambusao RIS and Jalaur RIS since laterals have become nonfunctional and main canal has been almost fully silted resulting in reduced discharge capacities and water delivery. These NIS have reported that there was no improvement in system performance when free irrigation was introduced in 2017.

Many farmers are still traditional and don't follow cropping calendar, as in the case of VSPC IA in BPIS. In fact, the Manupali RIS has no cropping calendar. The system will implement a cropping calendar this coming 2019 only.

Some IAs encountered illegal opening and closing of gates. This could be observed in the field wherein locks and security gates where installed to prevent illegal gate control (see sample in Photos 17 and 18).

Photo 17. Check gate with padlocks in Libmanan-Cabusao PIS

Photo 18. Section of Lateral C of Bayongan IS.
Take note of the chains with padlock on the turning mechanism of the gates.

Farm to market roads are also in poor condition in some IAs (e.g. New Life IA in MARIIS, Dagupan IA in Visitacion IS, Ambayoan-Dipalo RIS, and Balayungan RIS) and are not passable, especially during wet season.

On the environmental aspect, focusing on the determination of irrigation water quality such as pH, dissolved oxygen (DO), and electrical conductivity (EC) in main canals and laterals using water quality kits, it was found that most of the NIS main canal and laterals exhibited reasonably good water quality as reflected <300 uS/cm (EC), and > 6 ppm (DO). Most NIS cases showed pH levels on the alkaline side (> 7) which can be attributed to excess sodium, and can therefore lead to sodicity problem in the future and pose serious problem on water quality especially if this is combined with high salinity levels. In fact some NIS cases (especially those pumping ground water like TGIS) and due to sea water intrusion (e.g. Magapit PIS), salinity is a problem (i.e. EC is > 300uS/cm) which can pose serious effects on crop development and yield if not properly addressed. Another important water quality indicator which affects photosynthesis and thus biomass production is DO which was found to be low (i.e. 6 < ppm) in some NIS cases (e.g. downstream of Vaca dam and PDRIS end of downstream. This can be attributed to the thick aquatic vegetation just upstream of the Vaca dam which has caused the reduction of DO downstream. DO is very important in photosynthesis, which is responsible for biomass production. The effect of poor water quality, especially on crop productivity has not been established yet since data on yield of the different NIS cases visited are not yet available.

DO which was found to be low (i.e. 6 < ppm) in some NIS cases (e.g. Capayas and Bayongan IS, Binahaan-Tibak and Daguitan-Guinarona-Marabong RIS). Seven (7) sites in Capayas and Bayongan IS have shown low pH (<5) and low DO (around 4.5 ppm) indicating that it is acidic and is lacking in dissolved oxygen. All 12 sites in Leyte NIS have shown very low DO (around 1.5 ppm) indicating that it is deficient in dissolved oxygen. Normally, the DO increases going upstream since water in the source have less pollution. Some cases have different findings such as measurements in re-use dams which have more pollution. Although there was no measurement of this parameter in Iloilo NIS sites, there are some measurements in the other provinces. DO was found to be low (i.e. 6 < ppm) in some NIS cases such as 6/14 sites in Bukidnon, 8/12 sites in South Cotabato, and MalMar 2, 3/6 in M'lang and Padada RIS.

Some factors which affect the DO level are: a) the overabundance of organic matter like dead algae where aquatic aerobic bacteria can grow rapidly and consume oxygen during respiration, which decreases the amount of dissolved oxygen in watersheds; b) the low atmospheric pressure found at higher altitudes which slightly decreases the solubility of dissolved oxygen; and c) the mixing of air and water caused by swiftly flowing water over rocks, by wind, or thermal upwelling, which increases dissolved oxygen concentrations in a process called aeration. A body of water that is very stagnant may result in very low dissolved oxygen concentration. This was the case in Vaca dam where thick aquatic vegetation has reduced DO level as was reflected in the reading of only 1.1 ppm in the main canal downstream of the intake gate.

The EC, which reflects the salinity level of the irrigation water, ranged from 130 to 300uS/cm which is quite acceptable for crops (e.g. rice). There was only one case (in TGIS Tarlac) where EC was high (around 700 uS/cm). This can be attributed to the source of water, which is ground water pumping. Ground water is usually saline due to sea water intrusion or leaching of salts from irrigated lands. Another problem case with respect to salinity is the Magapit PIS in

Cagayan. During walkthroughs, it was observed that some areas are problematic (stunted crop growth) due to salinity problem because of the tidal intrusion of sea water caused by the collapse of dikes protecting the irrigated areas. Although the EC meter was not working during the visit, observations were verified by the guide (Engr. Laureo C. Bulseco) who attested that there was problem in crop development in areas near the collapsed dike due to high levels of salinity.

For the pH, which describes the acidity or alkalinity of the irrigation water, it was found that most of the NIS sampled showed pH values greater than 7 which is above neutral and considered alkaline. Alkalinity reflects the sodium content of irrigation water where high values can be hazardous to crops. Soil moisture with pH < 4 is called very acid and with pH > 10 very alkaline. The causes of soil alkalinity can be natural or man-made. The natural cause is the presence of soil minerals producing sodium carbonate upon weathering. The man-made cause is the application of irrigation water (surface or ground water) containing a relatively high proportion of sodium bicarbonates (Oosterbaan, 2003).

Most NIS cases in Visayas and Mindanao also showed pH levels on the alkaline side (> 7) which can be attributed to excess sodium, and can therefore lead to sodicity problem in the future and pose serious problem on water quality, especially if this is combined with high salinity levels. Most NIS cases in Iloilo showed pH levels on the alkaline side where 14 of 22 samples showed pH > 7. This was especially evident in all Jalaur RIS measurements (9 locations) where pH was greater than 7 and EC was greater than 300 uS/cm in 3 out of 10 locations. Salinity as reflected by high EC (i.e. >300uS/cm) was also a problem in all Sibalom-Tigbauan RIS sites where all 5 measured values from laterals, main canals, turnouts showed values greater than 400uS/cm and 2 out of 4 locations showed high pH. Salinity is a problem (i.e. EC is >) which can pose serious effects on crop development and yield if not properly addressed.

The DO level and pH of the water in a rice field are positively correlated. Both pH and DO levels are lowered during the time when respiration dominates and depending on the alkalinity (or buffering capacity) of the water, the diurnal variations can range from zero DO to super-saturation and from acidic to highly alkaline (pH>9.5) waters during times of algal blooms (Roger, 1996). Zhi (2000) also showed the relation between the dissolved oxygen in soil water and the days of submergence of deepwater rice. The results indicated that the days of submergence increased from 1 to 5 days when DO levels (mg/L) decreased from 7.8 to 0.6. But there was limited time to measure the diurnal and seasonal variations in DO (as a function of temperature, salinity, water depth, aeration, photosynthesis, respiration and decomposition) so its effect on yield cannot be established in this project.

Photo 19. Water quality measurement in paddy

Photo 20. Water quality measurement upstream of Parshall flume

Photo 21. Water quality measurement in a Lateral (Marbel #1 RIS).

Studies have shown that there was reduction in rice yield of about 0.57 – 0.75 tons per hectare per crop due to water pollution (Huynh and Yabe, 2012). Results seem to confirm this finding since some NIS sites in Visayas and Mindanao with high EC and pH and low DO could have also caused the low yield in those sites where rice yield have ranged from 70 to 100 cavans per hectare compared to other sites with high production (i.e. 150 cavan per ha) (see Table 10). For instance, in Barotac Viejo and Sibalom-Tigbauan RIS sites in Iloilo, yield was as low as 70 and 100 cavans per hectare, respectively, during first cropping due to high EC (> 400) and high pH (> 7). This was also true in Padada RIS and Marbel #1 RIS where yield was only 110 and 80 cavans per hectare respectively and this can be due to the effect of high EC and pH and low DO (<6ppm). Other systems with low yield are: CASANDEL IA and Merced Carmelo IA in Barotac Viejo RIS with 50 and 70 cavans respectively, TATAG IA, PAMPBU AND GUINTTU IA in Mambusao RIS with 40, 45, and 70 cavans respectively, Balatikan IA in Mlang with 80 cavans, Rice Field IA, Pagbidaet-Malipayon Center IA and CABUMADU IA in Marbel #1 RIS with 80 cavans, all downstream of Banga RIS with 70-80 cavans and Sinayawan Lat G6 IA in Pulangui RIS with 80 cavans. These systems also reflect low water quality in terms of one or two of the water quality parameters.

It can be seen from Table 10 that Visayas IAs seem to perform better than IAs in Luzon and Mindanao where 23% and 77% of IAs in Visayas got yield of <100 and >100 cavans per ha, respectively during the 1st cropping. In the 2nd cropping, similar trend was observed where Visayas got 30% <100 and 70% >100 cavans per ha. Mindanao productivity even got lower during 2nd cropping where <100 cavans per ha was 55% compared to only 45% >100 cavans per ha. This consistent performance in production of IAs in Visayas can be attributed to a number of factors foremost of which is the availability of water due to the lining of canals from upstream to downstream (e.g. Bohol) so bank erosion and water losses due to seepage and percolation are controlled compared to those earth canals (unlined) in other systems. Looking at the effect of water quality on yield, it appears that those IAs that meet the threshold values for pH, DO and EC seem to have better yield. The water quality of different NIS was presented in Table 11 where environmental factors as reflected in the 3 water quality parameters are shown. Those NIS with low water quality seem to also have lower yield and this is consistent with data found in literature where water quality reduces yield by 0.57 to 0.75 tons/ha or equivalent to 11.4 to 15 cavans per ha.

But there are other factors that can cause low yield other than poor water quality such as lack of inputs (fertilizer and water) and crop and soil management which has to be verified with more data.

Table 10. Summary of IAs productivity (yield in cavans per ha) in Luzon, Visayas, and Mindanao

Province	1st cropping (cavans/ha)					2nd cropping (cavans/ha)				
	<40	41-64	65-99	>100	Ave	<40	41-64	65-99	>100	Ave
Luzon										
Quezon	0	0	3	0	87.00	0	0	2	1	90.00
Cavite	0	0	3	0	80.00	0	1	2	0	68.33
Ilocos Norte	0	0	2	1	90.00	0	0	2	1	106.67
Ilocos Sur	0	0	1	3	97.50	0	0	0	4	135.00
Pampanga	0	0	2	2	87.50	0	1	2	2	80.00
Isabela	0	0	0	9	131.11	0	0	1	8	112.78
Nueva Ecija	0	0	1	7	120.00	0	0	6	2	95.00
Bulacan	0	0	1	1	119.00	0	0	0	2	110.00
Cagayan	0	0	3	6	123.89	0	2	1	5	90.63
Occidental Mindoro	0	0	1	2	103.33	1	1	1	0	60.00
Pangasinan	1	0	2	2	91.60	0	1	2	1	80.00
Tarlac	0	0	1	2	106.67	0	0	0	3	130.00
Camarines Sur	0	0	2	1	86.67	0	1	2	0	76.67
Total no. of IA's	1	0	22	36	101.87	1	7	21	29	95.01
%	1.69	0.00	37.29	61.02		1.72	12.07	36.21	50.00	
Visayas										
Bohol	0	0	9	5	94.71	0	0	6	8	100.71
Leyte	0	0	5	7	101.07	0	0	10	2	90.81
Iloilo	0	0	12	5	93.61	0	1	12	4	85.68
Capiz	0	3	2	0	63.80	0	1	2	0	63.79
Total no. of IA's	0	3	28	17	88.30	0	2	30	14	85.25
%	0.00	6.25	58.33	35.42		0.00	4.35	65.22	30.43	
Mindanao										
Davao del Sur	0	0	0	5	132.00	0	0	0	5	129.60
North Cotabato	0	0	2	4	103.20	0	0	2	4	104.27
South Cotabato	0	0	3	9	106.23	0	0	7	4	96.57

Province	1st cropping (cavans/ha)					2nd cropping (cavans/ha)				
	<40	41-64	65-99	>100	Ave	<40	41-64	65-99	>100	Ave
Maguindanao	0	0	2	0	91.80	0	0	1	1	109.80
Bukidnon	0	0	7	7	118.79	0	0	6	8	111.38
Total no. of IA's	0	0	14	25	110.40	0	0	16	22	110.32
%	0.00	0.00	35.90	64.10		0.00	0.00	42.11	57.89	

Table 11. Summary of the technical, institutional and environmental issues in the National Irrigation Systems in the Philippines

	Technical Issues	Institutional Issues	Environmental Issues
Pampanga	Most laterals are earth canals	Experienced pest infestation in 2013 due to 5 in 2	Water quality measurements or information are lacking in all NIS cases visited.
	There is double pumping of water from drainage (Pump operating cost is P3000 per ha	Farmers only get break-even thus cannot pay the ISF	Water quality parameters such as dissolved oxygen (DO), electrical conductivity (EC), and pH are measured in the field to determine the quality of water in the main canals, laterals, and paddies. Acceptable values for these indicators are 6 to 7 (pH), <300 uS/cm (EC), and > 6 ppm (DO) (see Tables below for details).
	Need to improve irrigation facilities (e.g. turnout gates)	Conflict arises due to difficulty in convincing other members to pay the ISF	Measured water quality in the downstream part of PIDRIS showed low DO levels of 2.7 ppm.
	Rehabilitation of damaged canals	NIA has no adequate funds for major repair and rehabilitation	pH values are greater than 7 which is above neutral and considered alkaline.
	Main canal of PDRIS is already highly silted, around 40%, due to lahar	Reshuffling of management affects prioritization of programs which leads to delay or cancellation	However the other parameters like EC is not a concern.
	Silt levels were measured to be around 10 cm- 41 cm	Conflict arises due to difficulty in convincing other members to pay the ISF	
		Illegal pumping and garbage dumping	

	Technical Issues	Institutional Issues	Environmental Issues
Nueva Ecija	Target improvements are: to restore approximately 100 hectares in addition; modify check structures; improve canal linings to reduce losses	Previously, support from NIA is very good. However, it drastically decreased as of 2006 because of cost cutting measures followed by RAT Plan	The lateral downstream of Vacca Dam exhibited very low DO of 1.1 ppm. This can be attributed to the thick aquatic vegetation just upstream of the Vacca dam which caused the low DO downstream.
	Some members use surface pumps which increases their cost from P3000 – P5000 (per ha)	Usual conflict is due to distribution of water	pH values are greater than 7 which is above neutral and considered alkaline
	LTRIS dam damaged due to typhoon Mario	High prevailing prices of inputs while selling prices of harvest is low	However the other parameters like EC is not a concern.
	Farmers experience delay and occasional shortage of water	Institutional Issues	Environmental Issues
	Earth canals are very prone to damage and siltation	Weak policy enforcement on informal settlers	No water quality data since measurement or water quality monitoring is not done.
	Declining water supply due to heavy siltation of Peñaranda river	Initially, the IA constructed brush dams in order to store water. However, due to a dike construction by the DPWH, the water that flows to the brush dam and eventually to the canal is blocked.	Measured pH values are greater than 7 which is above neutral and considered alkaline.
	Heavy siltation is due to poor watershed management		However the other parameters like EC and DO are not a concern.
	Water source is too far (Pantabangan dam), thus even if the dam is full, water has to travel a very long distance before it reaches the division		No water quality data since measurement or water quality monitoring is not done
	Highly recommend to continue the proposed Balintingol dam where it could store water near Division 4 area		
	Informal settlers along the canal is a		

	Technical Issues	Institutional Issues	Environmental Issues
	main problem due to solid waste		
Ilocos Norte	Constant repair of brush dams	The constructed dike was too high such that water can no longer flow through the irrigation canal	Measured pH values are greater than 7 which is above neutral and considered alkaline.
	There is a constant need to put up a brush dam in order to store water specially during dry season	The design was contested to DPWH but DPWH said that it was approved by the Mayor. On the other hand, the Mayor said that he cannot do anything because that was the design of the DPWH.	However the other parameters like EC and DO are not a concern.
	Common conflict is due to improper use of turnouts and scheduling of water distribution	In addition, the issue is affected by political complexities since the water source is in a different municipality	No water quality data since measurement or water quality monitoring is not done
	During wet season, the canal is blocked by heavy siltation due to quarrying activities in the area. Therefore, a channeling canal of 3kms was constructed around for the water to flow.	Improper use of turnout and scheduling of water distribution	Measured pH values are greater than 7 which is above neutral and considered alkaline.
	The cost of excavation for desilting is P100k per excavation	High prices of inputs while low prices of harvest	However the other parameters like EC and DO are not a concern.
	A river channeling project was proposed worth P20 million but the budget was reduced to P7 million. Since the cost was reduced, it was instead used to restore canals.	Illegal pumping	
	But farmers would opt to have it used to purchase a back hoe for excavation use instead.	Not enough clearing subsidy	

	Technical Issues	Institutional Issues	Environmental Issues
	Dilapidation of canals and turnouts are also aggravated by the heavy siltation from the river	No water during scheduled delivery	
	The heavy siltation is due to quarrying	Stealing of water	
	Lack of irrigation facilities		
	Slow rehabilitation of damaged canals		
	Unfinished structures		
	Use of pump because canal elevation is lower than the farm elevation		
Capiz	Lack of farm machineries	High cost of farm inputs, Low cost of rice product	3 out 5 sites in Mambusao, Capiz NIS have high pH (>7) which indicates that the water is quite alkaline. But the EC reading is ard 160 uS/cm which is OK. There was no reading of DO in Mambusao.
	Need to improve irrigation facilities	High cost of fertilizer and labor	
Bohol	Slow rehabilitation of damaged canals and FMR	Illegal pumping and garbage dumping	7 sites in Capayas and Bayongan, Bohol NIS have shown low pH (<5) and low DO (ard 4.5ppm) indicating that it is acidic and is lacking in dissolved oxygen. But EC is ard 200 uS/cm which is OK in terms of salinity level.
	Lateral C is partially filled with stones	Less than 100% collection efficiency of Annual Dues	
	Abandoned area (reuse point)	High cost of farm inputs, low cost of rice product	
		Lack of manpower in canal cleaning	
	No water during dry season	Stealing of water and illegal check structures	
	Lack of postharvest facilities		
	Need for dam heightening		

	Technical Issues	Institutional Issues	Environmental Issues
Leyte	Slow rehabilitation of damaged canals and farm to market roads (FMRs)	Not enough water for the whole system	12 out of 12 sites in Binahaan and Daguitan Leyte NIS have shown very low DO (ard 1.5ppm) indicating that it is deficient in dissolved oxygen. But EC is around 200 uS/cm which is OK in terms of salinity level and pH is ard 6 which is on the neutral side.
	Needs farm machineries for canal cleaning and postharvest activities	Stealing of water	
	Siltation of canals	Delayed water delivery	
		High cost of farm input, low cost of rice product	
		High labor cost	
		Infestation (Stem borers and rats)	
Iloilo	Need to improve irrigation facilities	High cost of farm inputs, low cost of product	Most NIS cases in Iloilo showed pH levels on the alkaline side where 14 of 22 samples showed pH > 7. This was especially evident in all Jalaur measurements (9 locations) where pH was greater than 7 and EC was greater than 300 uS/cm in 3 out of 10 locations.
	Slow rehabilitation of damaged canals and demolished structures	Stealing of steel gates	Salinity as reflected by high EC (i.e. >300uS/cm) was also a problem in all Sibalom-Tigbauan sites where all 5 measured values from laterals, main canals, turnouts showed values greater than 400uS/cm and 2 out of 4 locations showed high pH (>7).
	Needs drainage structures	Drainage outlet draining into the canal	
	Silted canals	Shortage of water	
		Delayed water delivery	
		Illegal turnouts	
Davao del Sur	Many portion of the canal system are unlined	High cost of farm input, low cost of palay	DO is <6ppm, EC > 300 uS/cm and pH >7 in 4 out 5 NIS sites in Padada Davao del Sur, which are indicative of the low quality of water in the area.
	Damaged steel gates	High cost of fertilizer	

	Technical Issues	Institutional Issues	Environmental Issues
		Members are not paying the Association Sustainable Dues	
North Cotabato		Low subsidy; Not all IAs have offices	4 out of 6 sites in M'lang North Cotabato have DO <6ppm, 3 out 6 sites have pH >7 which means that some sites in the area have low water quality in relation to these indicators. However, EC <200uS/cm for all 6 sites which indicates that salinity is not a problem in the area.
	Slow repair and rehabilitation of farm to market roads (FMRs)	Water shortage	In Malmar RIS, 2 out 2 sites have pH> 7 and DO < 6ppm indicating low water quality. However, EC is OK since it's around 150 uS/cm for the two sites.
	Needs new heavy equipment	Flooding in low-lying areas	
	Unfinished lining of canals	Delayed water delivery	
South Cotabato	Silted canals	Delayed response on reports of water stealing and damaging of structures	12 out of 12 NIS sites in Marbel and Banga South Cotabato have pH >7, 8 out of 12 have DO <6 ppm which indicates low water quality in most sites in South Cotabato. However only 2 out 12 sites have EC > 300 uS/cm which are located in downstream part of Marbel sites
	Need back hoe for cleaning	Contaminated water	
	Unfinished lining of the canals	Water shortage	
	Unfinished construction of supplementary dams	Presence of debris	
		Difficulty in collecting O&M dues	
		High cost of inputs, low price of products	
		Lack of government support	

	Technical Issues	Institutional Issues	Environmental Issues
Bukidnon	Too much water distribution losses especially in unlined canals	Lack of funds and subsidy	13 out of 14 sites in Pulangui, Roxas Kuya, and Manupali Bukidnon NIS have pH > 7 and 6 out of 14 sites have DO < 6ppm which indicate low water quality. However, EC is around 100 uS/cm which shows that salinity is not a problem in the area.
	Needs back hoe for desilting	No action on requests for repair and rehabilitation	
		Pest infestation that lowers the farm output	
	Slow repair and rehabilitation of irrigation structures	Lack of water in downstream areas	
	Flooding and siltation especially during wet season	Rapid land conversion from farmland to residential	
		Most IA members do not cooperate on meetings and activities	
		High cost of farm inputs and low price of products	

Source: Authors' compilation

Although this section only covers UPRIIS and MARIIS (Luzon); Malinao IS and Jalaur-Suague RIS (Visayas); and Padada RIS and Marbel #1 RIS (Mindanao), other discussions with corresponding maps, photos figures and tables are presented in Annex C.

5.1.1. Upper Pampanga River Integrated Irrigation System (UPRIIS)

Three divisions of UPRIIS (2, 3 and 4) were visited. Siltation problems (see Photo 22) exist across all sections of the canal network which again points to the technical deficiency in the maintenance of the canal network. This is even worst in unlined canals which are eroded and damaged by uncontrolled animals frequenting the sides of the canals. As observed in other NIS, similar concerns exist such as lack of staff gauges to measure flow, siltation of canal up to lateral level, illegal pumping, garbage dumping in canals due to illegal settlers (Photo 23) and lack of maintenance were also observed in UPRIIS. Water shortage is expected to occur during El Nino this year. Another major issue is the collapse of LTRIS dam (see Photo 24) due to typhoon Mario in 2014.

Photo 22. Silted MC of LTRIS, Division 2, UPRIIS

Photo 23. Direct household refuse into MC of Division 4, UPRIIS

Photo 24. LTRIS dam damaged due to Typhoon Mario

UPRIIS was able to irrigate at most 114,000 hectares, however due to the declining water this is now reduced to around 86,000 hectares (Table 12). Some notable issues of UPRIIS were the declining water supply due to El Nino and prolonged drought. Reduction of irrigated area was due to declining inflow in Pantabangan dam and other intakes. As shown in the cropping intensity in the last ten years, there were years that it reaches to near 200%. To maximize water, re-use dams were constructed like the one visited Vaca dam (Division II) and Campana dam (Division IV). Moreover, some farmers are using LLPs and STWs (Photo 25) to supplement irrigation during low water supply.

Table 12. FUSA, programmed and total irrigated area of UPRIIS for 2014 Dry Season

DIVISION	FIRMED-UP SERVICE AREA, ha.	PROGRAMMED AREA, ha.	TOTAL IRRIGATED, ha
I	20,651.71	15,475.54	11,051.00
II	23,190.96	18,033.02	18,033.00
III	32,970.11	24,065.00	24,065.00
IV	24,977.00	14,864.00	14,889.00
V	15,291.00	11,549.16	9,409.00
CMIPP II	2,559.00	1,871.00	1,114.00
UPRIIS	119,639.78	85,857.72	78,560.00
Percentage Accomplishment, %			91.50

(Source: UPRIIS Briefer 2015) (As of January 15, 2015)

Heavy siltation could be observed especially in the mid and downstream area of UPRIIS. In the soil erosion map shown in Figure 5, moderate to severe erosion could be observed in the watershed area of UPRIIS. Watershed area is the upper and right side part of Figure 5. Other than watershed as silt source, siltation may be due also to erosion of unlined canal (Table 13) and inflows in the unlined Main Canals. Inflow from Pantabangan dam and other river intakes into Divisions II, III and IV uses the river network as the Main Canal as shown in Figure 3.

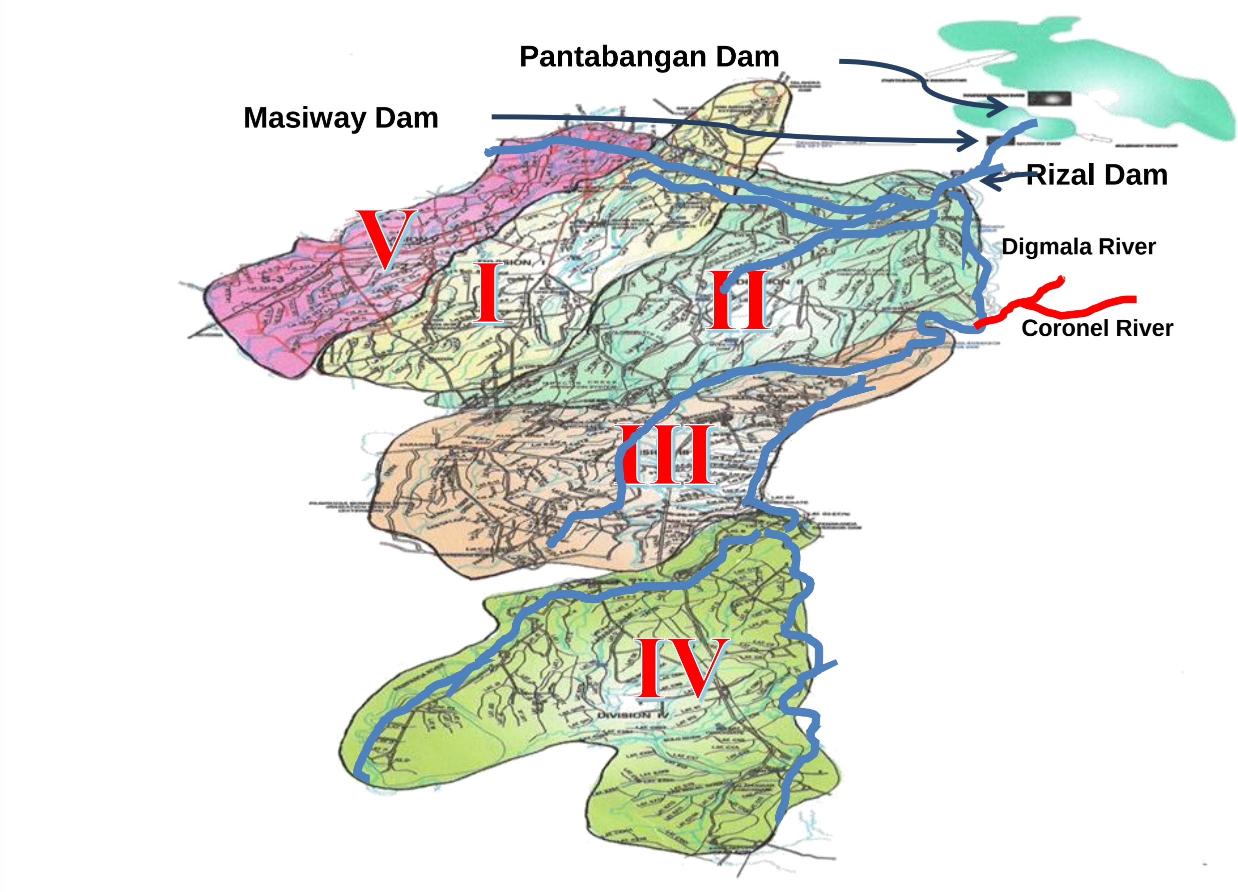
Table 13. Profile of canal lining of UPRIIS

Diversion Canal, km.	75.84
Length of Main Canal, km.	197.36
Length of Lateral, km.	1,455.728
Lined Canal, km.	467.14
Earth Canal, km	523.845
Length of Service Road, km.	1,563.954
Length of Access Road, km	368
Number of Turnouts	4,550

(Source: UPRIIS Briefer 2015)

Photo 25. STW in Division II, UPRIIS

Figure 3. Irrigated area of the different Divisions of UPRIIS



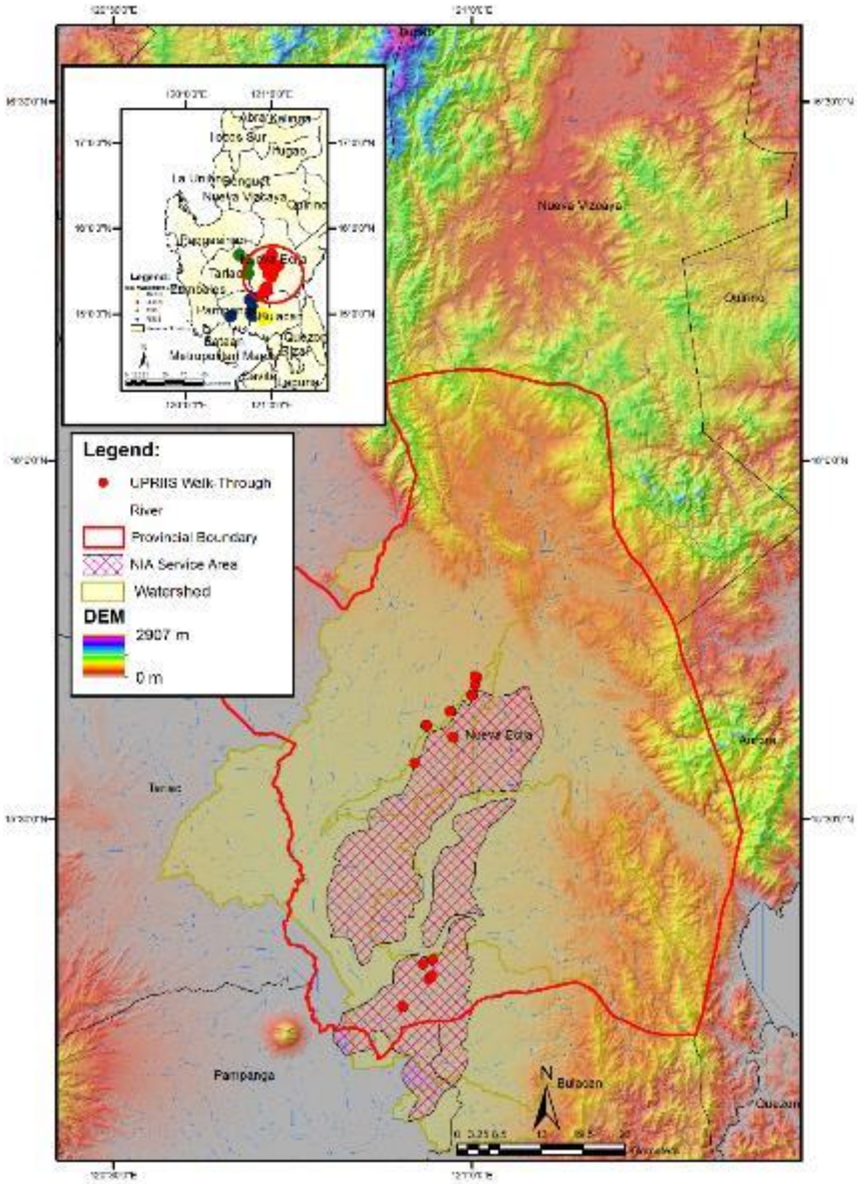
The DEM map, soil erosion map, slope map, built-up area map and overlaid maps of UPRIIS are shown in Figures 4 to 12. The overlaid maps show the reduction in service area in terms of the different component maps. The overlaid maps show the reduction in service area in terms of the different component maps. From the Erosion Map, the delineated FUSA was overlaid to determine the erodibility of the soil within the FUSA as shown in Figure 6. These show reduction in FUSA by 3% in terms of the erodibility of the soil alone. In Figure 7, the Map of Major Built-up areas are shown as digitized from Google Earth image (as of 2015).

The slope derived from remotely sensed DEM image is cropped by the delineated FUSA and are shown in Figure 9 after which the slopes of 0%-3% and 3%-8% were chosen to be desirable and are presented in Figure 10. The resulting maps show a reduction in service area by 0%.

The soil type map from BSWM Reconnaissance Survey obtained by DA-BAR was incorporated in the FUSA and is shown in Figure 10 with maps showing the desirable soil type (done by removing the sandy soils) which show a reduction in service area by 17%.

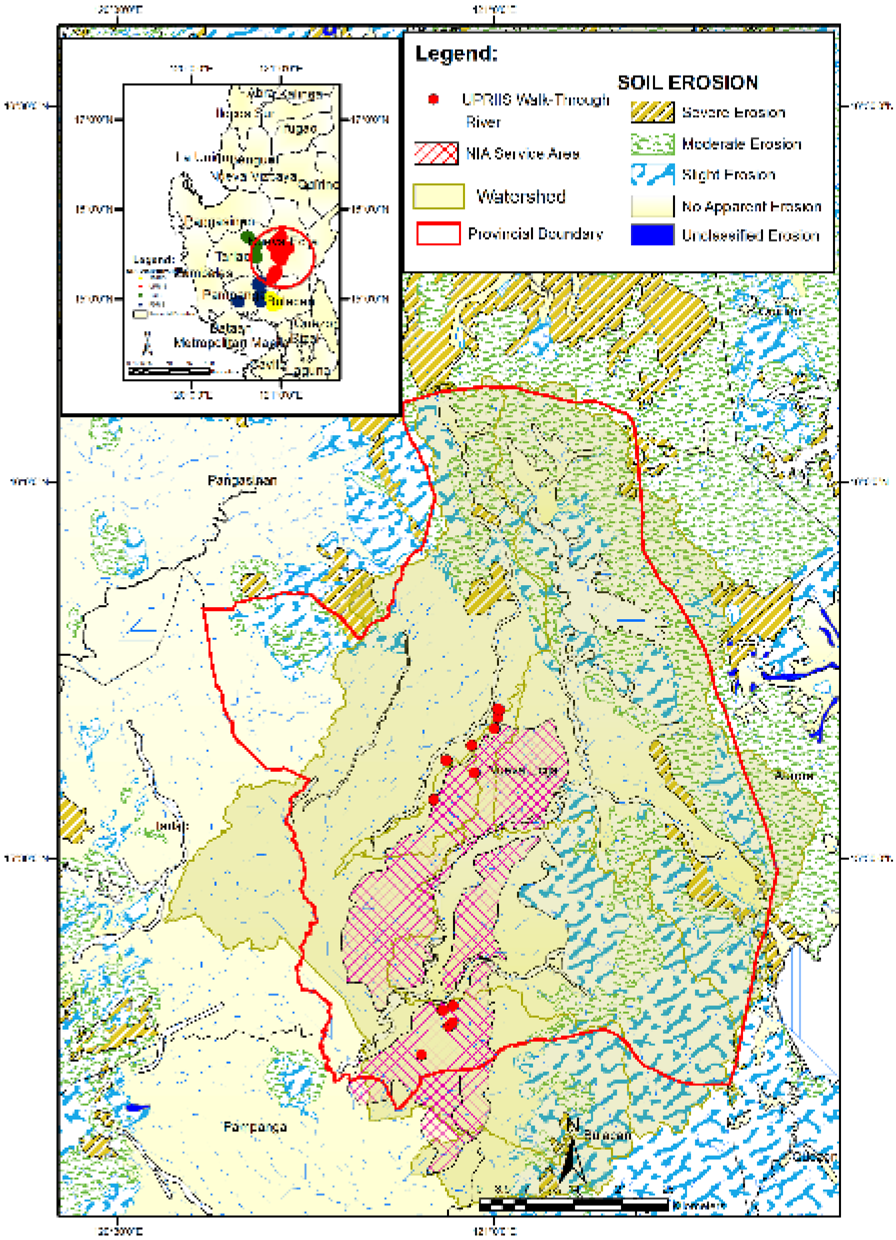
Using these 4 individual maps (erosion, slope, soil type, and built-up areas) with values showing desirable vs undesirable properties, they were overlaid using the Map Algebra function of GIS incorporating the 'Boolean' algebra, this resulted to final overlaid maps as shown in Figures 11 and 12. The reduction in the service area is 25%. This result just implies that only 75% of the total FUSA for UPRIIS is just available for farming which may result to optimum yield given a favorable condition. But this doesn't imply that you can no longer use the undesirable FUSA. This may just help to explain why some farmers obtain unfavorable crop yields. Moreover, the resulting maps and reduction values may be subjected to accuracy and reliability of the obtained secondary data.

Figure 4. DEM Map of UPRIIS, Nueva Ecija



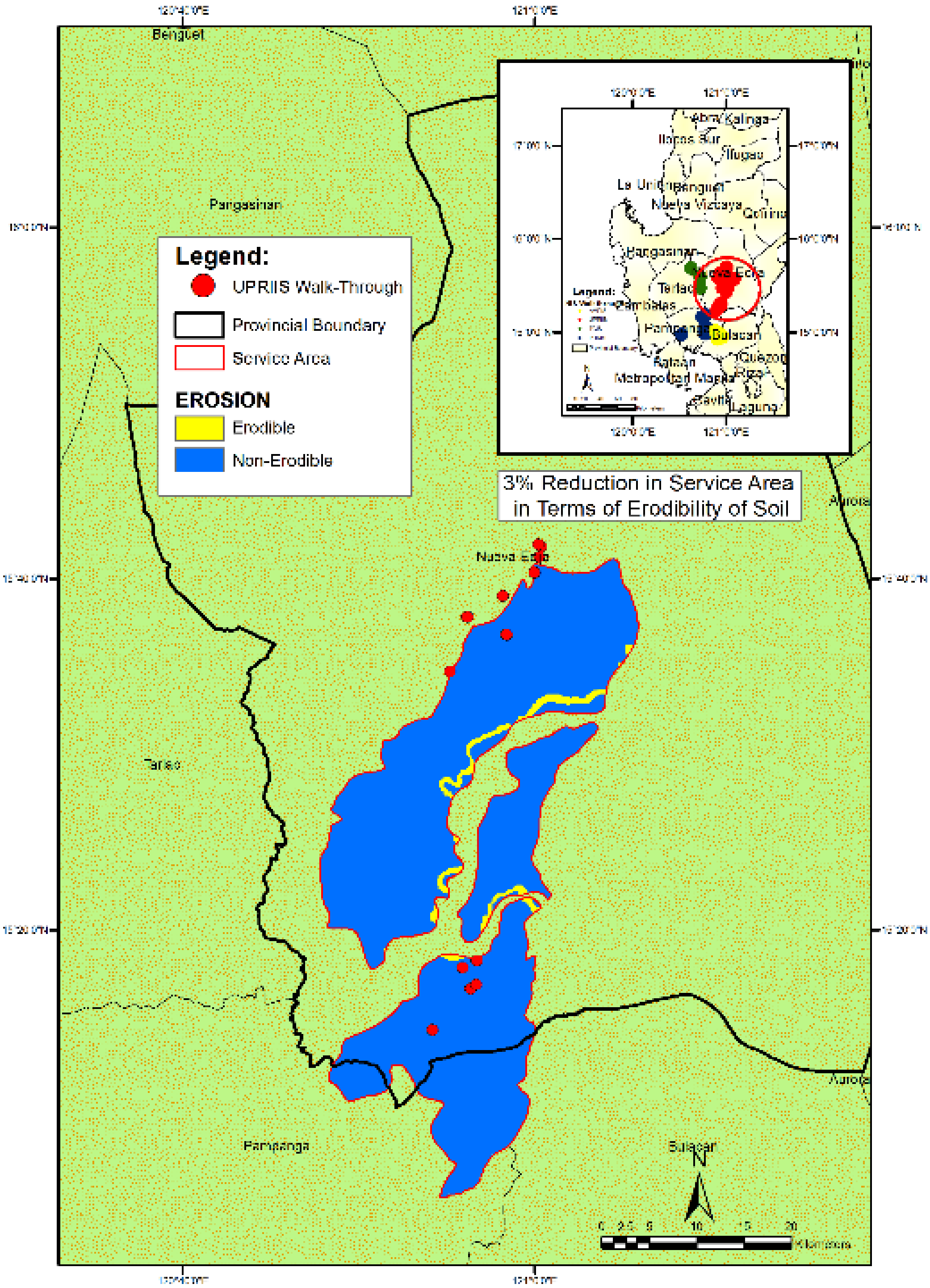
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 5. Soil erosion map of UPRIIS, Nueva Ecija



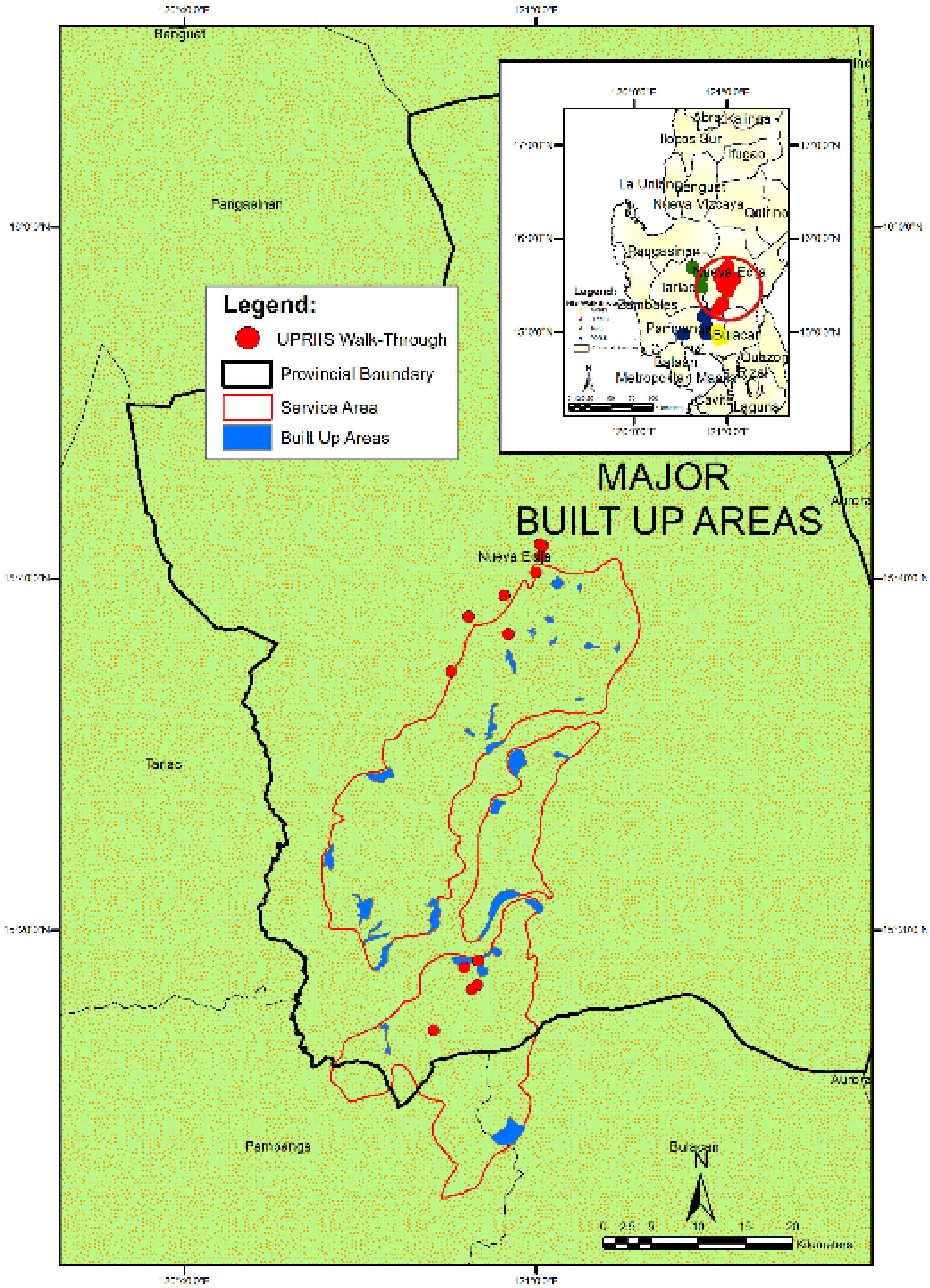
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 6. Overlaid map of UPRIIS, Nueva Ecija showing reduction in service area in terms of erodibility of soil



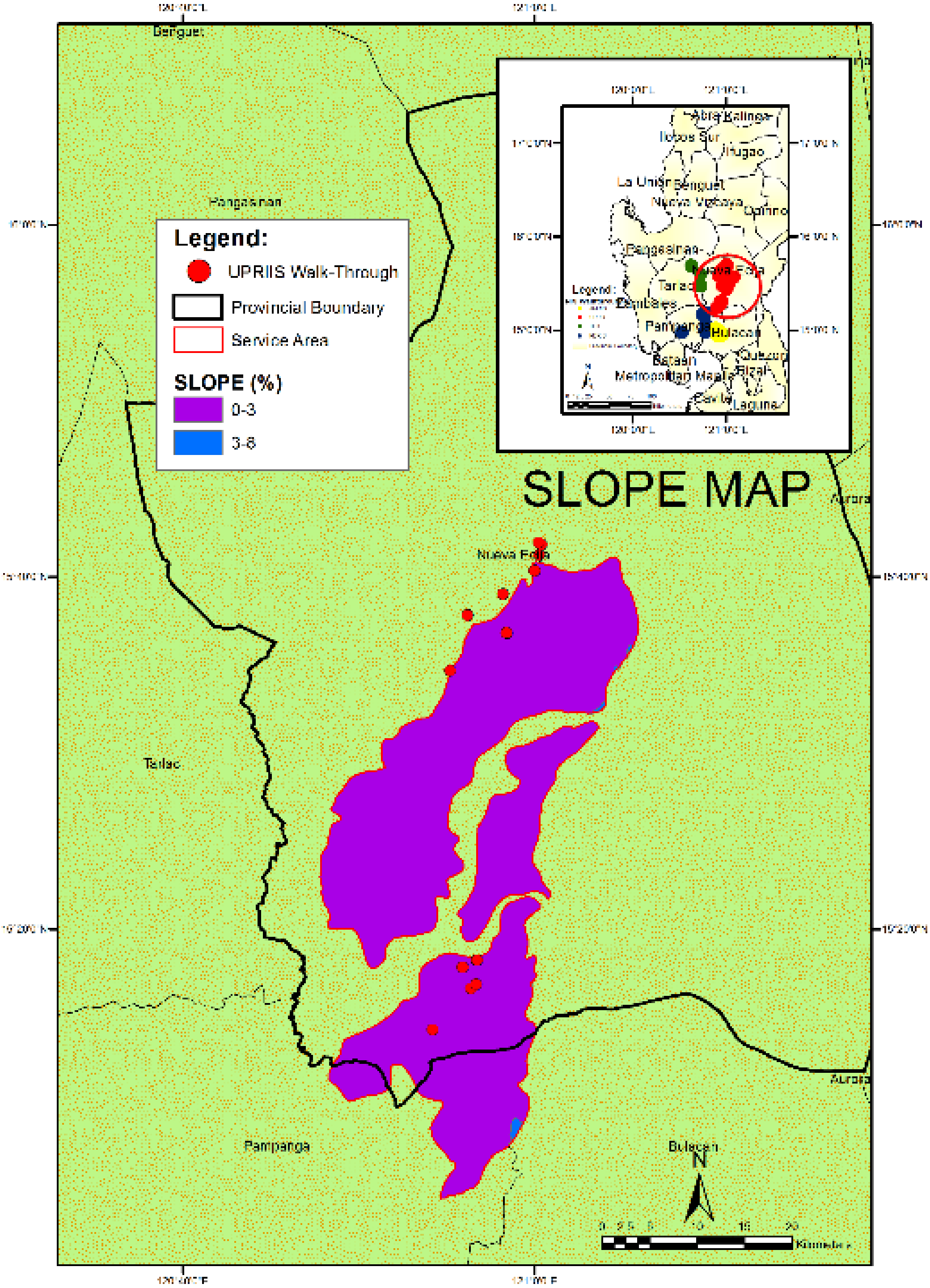
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 7. Built-up area map of UPRIIS, Nueva Ecija



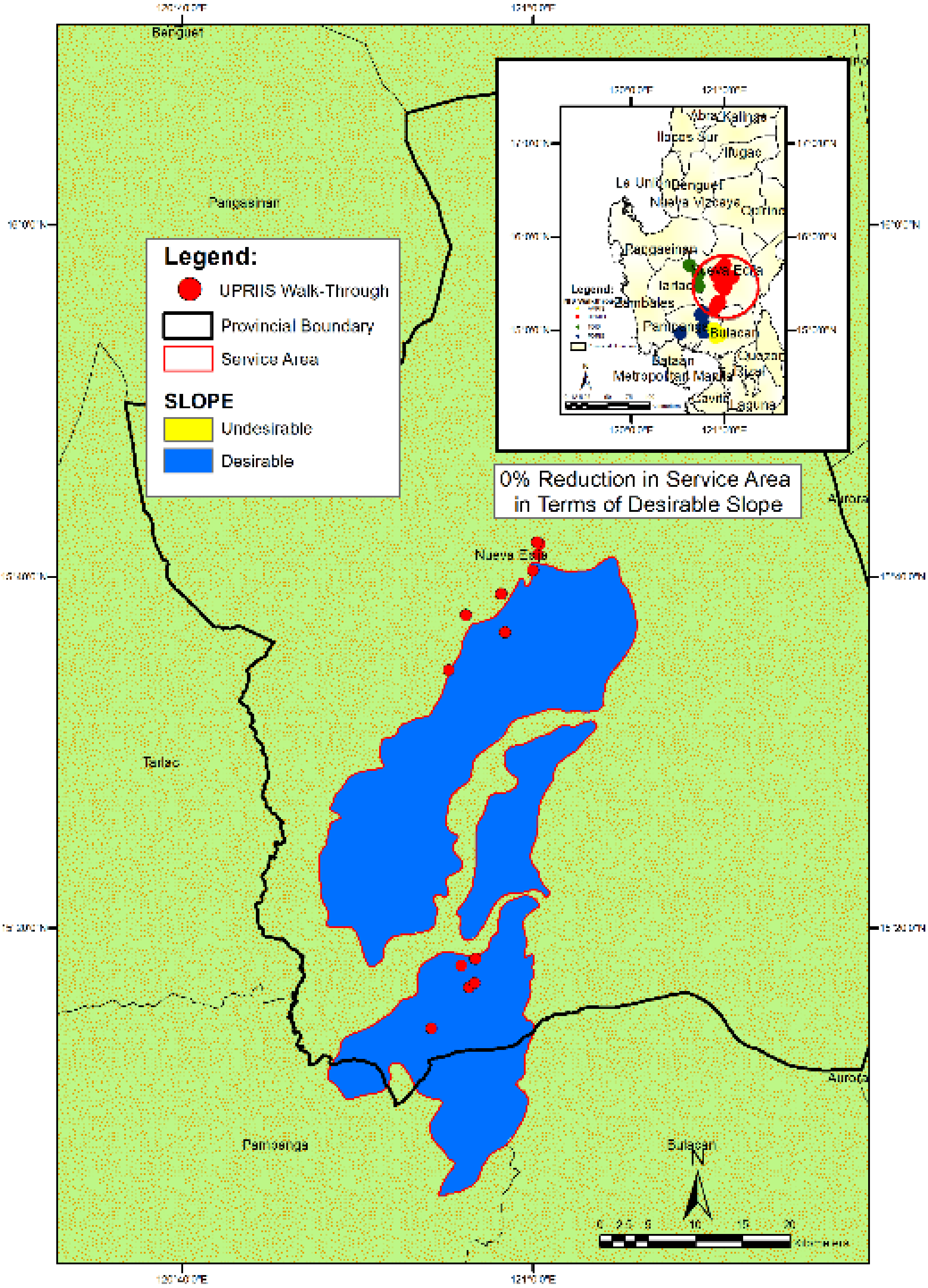
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 8. Slope map of UPRIIS, Nueva Ecija



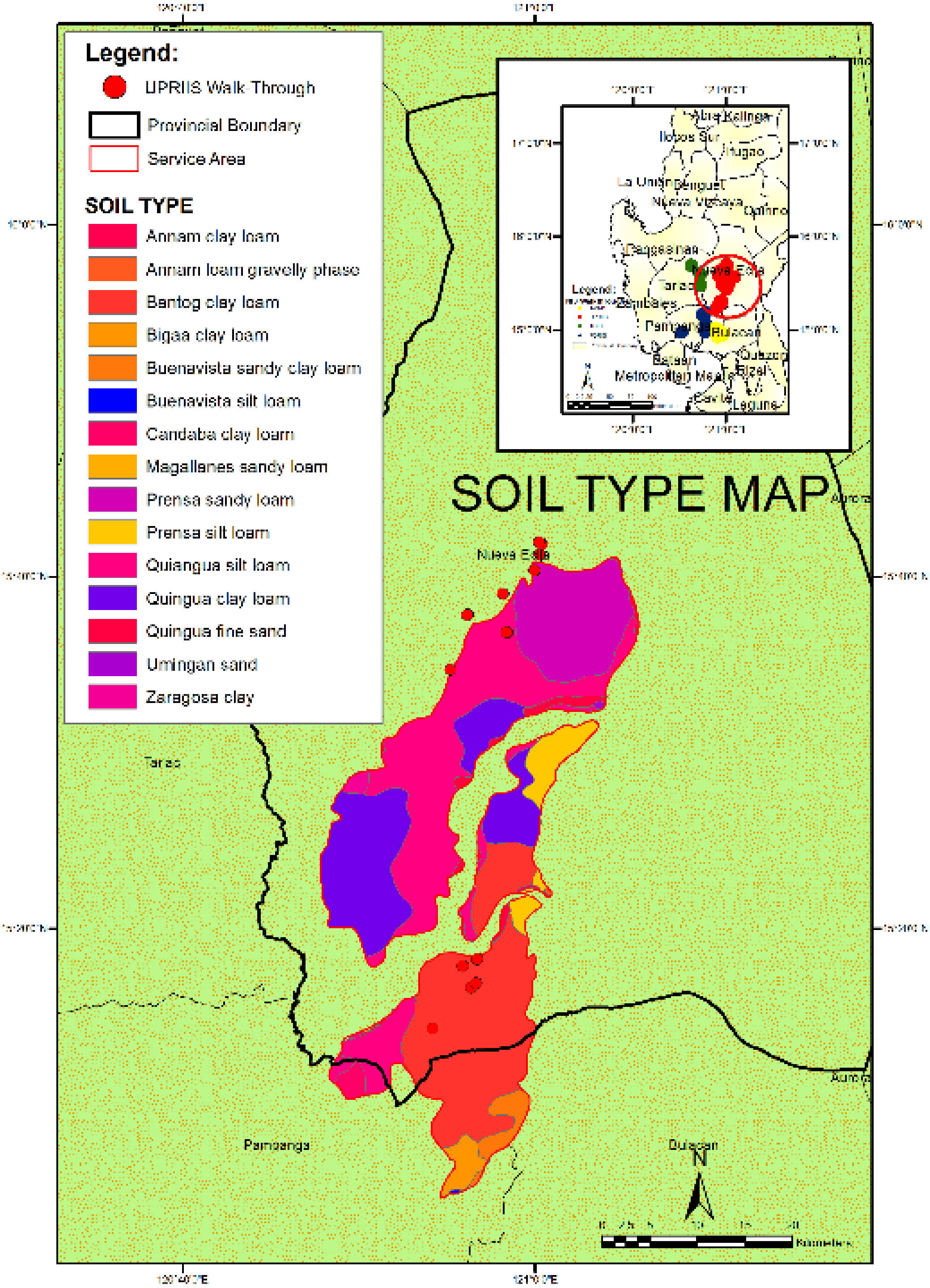
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 9. Overlaid map of UPRIIS, Nueva Ecija showing reduction in service area in terms of desirable slope



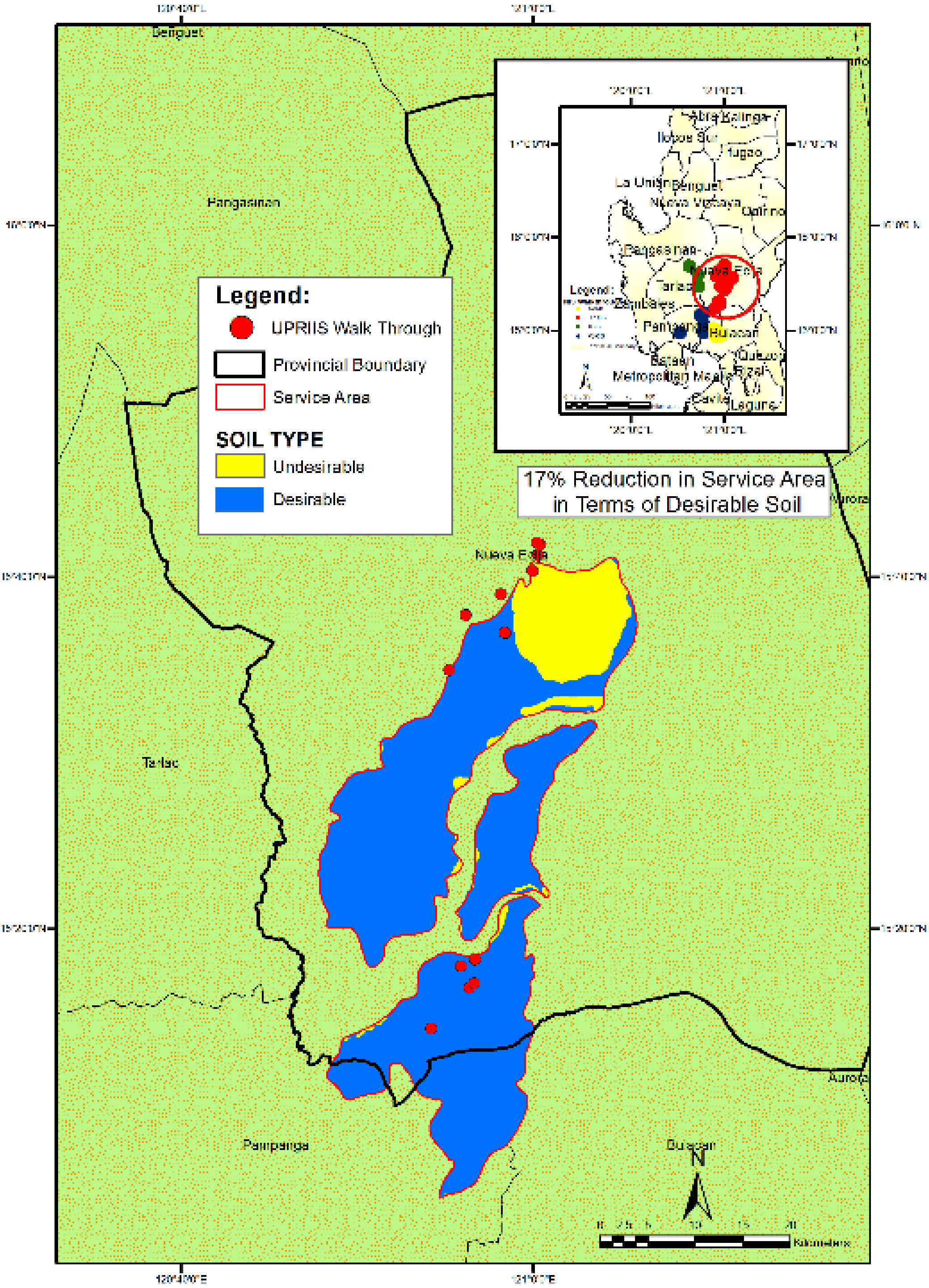
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 10. Soil map of UPRIIS, Nueva Ecija



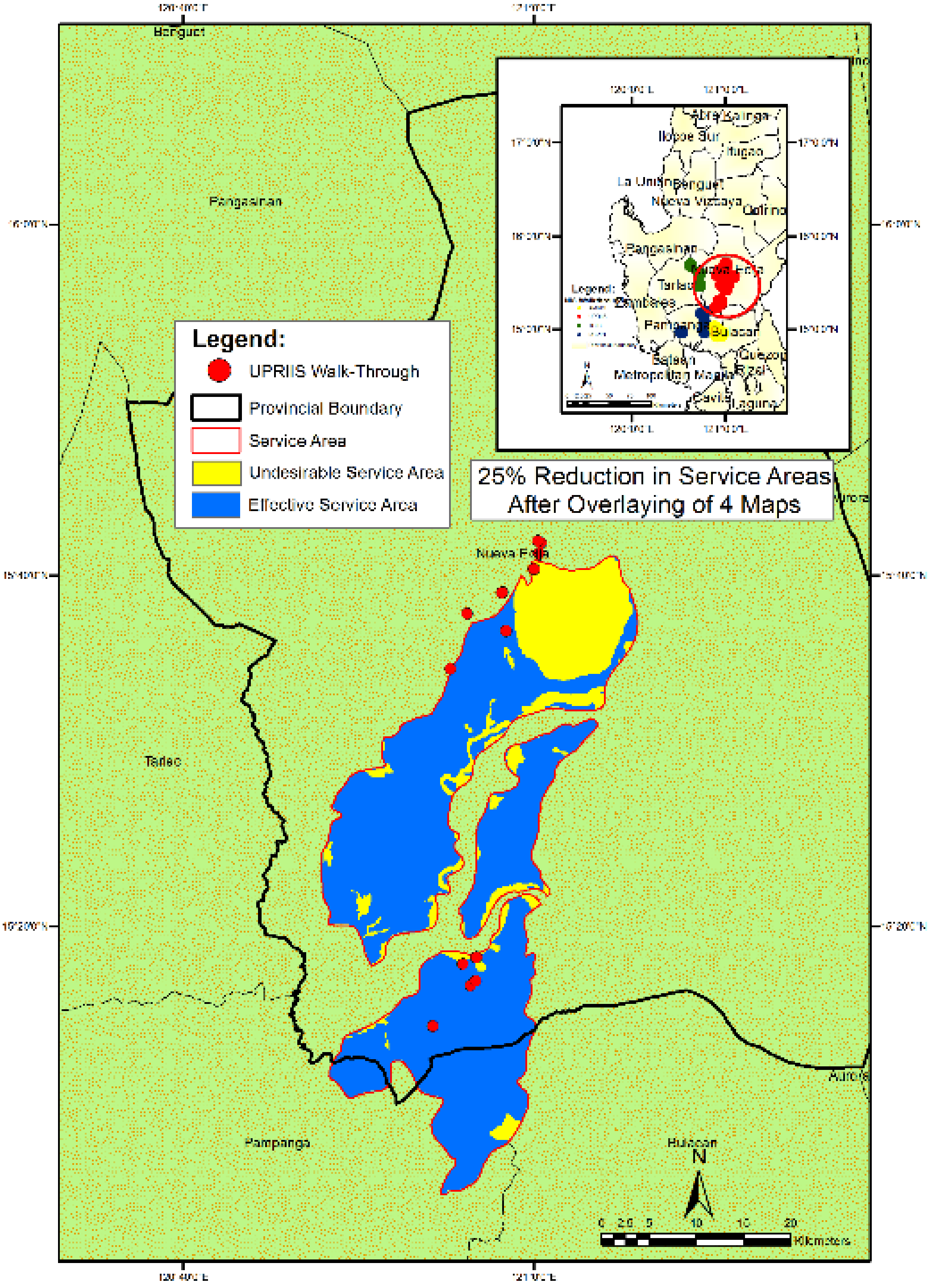
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 11. Overlaid map of UPRIIS, Nueva Ecija showing reduction in service area in terms of desirable soil



Sources: NAMRIA; NIA; DA BAR Metadata

Figure 12. Overlaid map of UPRIIS, Nueva Ecija showing reduction in service area



Sources: NAMRIA; NIA; DA BAR Metadata

Table 14. Performance indicators for UPRIIS

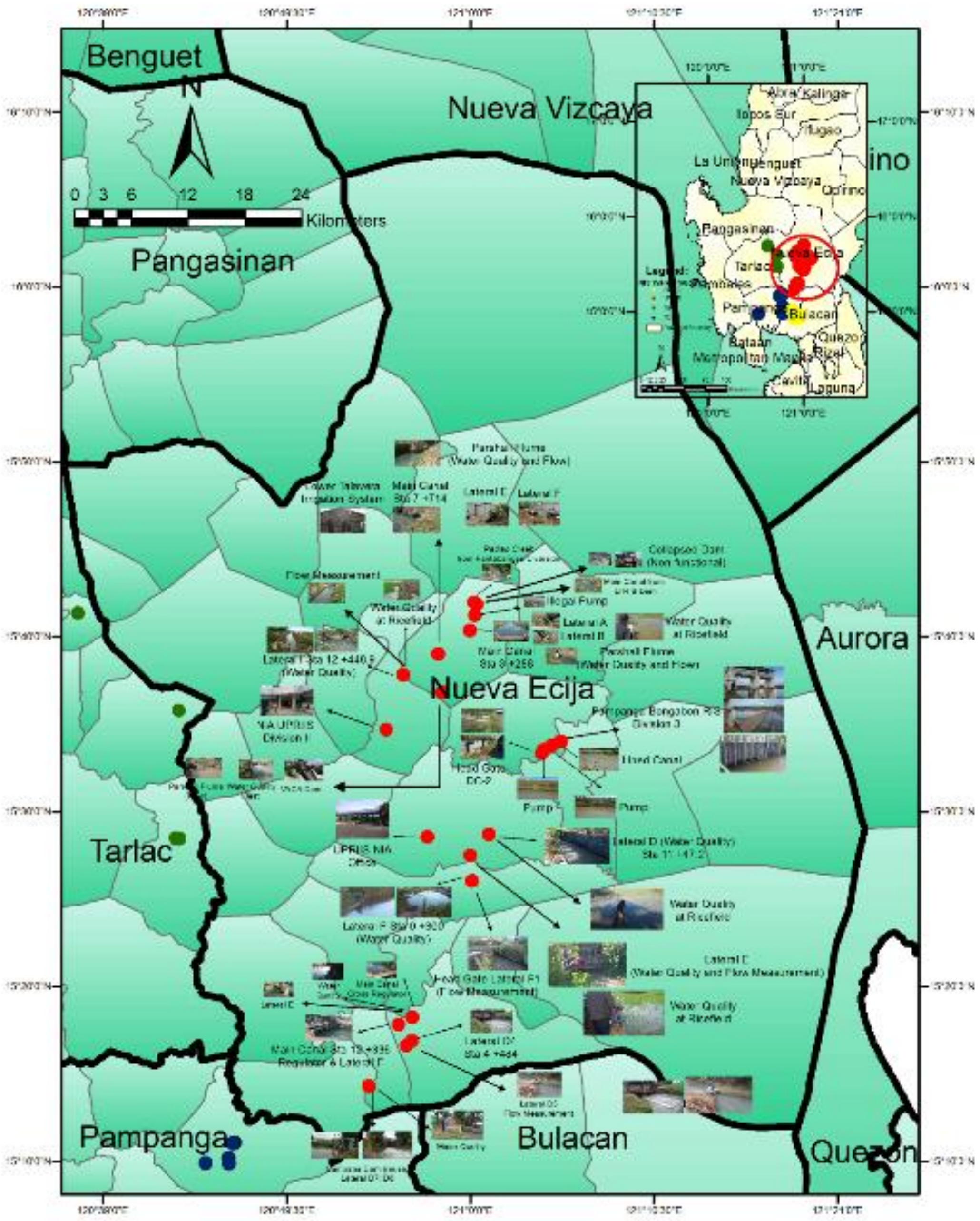
PERFORMANCE INDICATORS	DIVISION I *(9-year data)*		DIVISION IV *(5-year data)*		DIVISION V *(5-year data)*	
	Dry Season	*Wet Season*	*Dry Season*	*Wet Season*	*Dry Season*	*Wet Season*
Relative Water Supply [RWS][1] *(m^3/ m^3)*	1.26	1.23	1.09	3.06	1.27	2.20
Irrigated Area Performance [F][2]*(%)*	81.61	86.10	96.8	86.5	80.7	78.6
Gross Irrigation Water Quota [M][3] (m^3/Ha)	15,380	6,578	10,672	13,339	17,102	8,339
Yield Per Unit Area [Y][4] (kg/Ha)	5,680	3,778	4,397	3,845	6,730	4,710
Yield per unit Quantity of Irrigation water [Yw][5] (kg/ m^3)	0.37	0.57	0.47	0.32	0.40	0.61

*No or lacking parameter data for Division II and III

(Source: NUWAM Project)

Figure 13 shows the actual NIS walkthroughs for the three divisions (II, III, and IV) of UPRIIS. Location of NIA UPRIIS Division II office as well as the Vaca dam and office of Lower Talavera Irrigation System together with different canal structures with corresponding coordinates of flow and water quality measurements can be seen at the upper portion of the map. At the middle portion are the locations of Pampanga-Bongabon River Irrigation System of Division III together with its different laterals (D, E, F, and F1). The location of water quality and flow measurements can also be seen in this location. The lower portion of the map shows the structures that can be seen in the Division IV of UPRIIS. Downstream portion of Laterals E and F as well as laterals D4 and D5, and Campana Dam's laterals D7 and D8 can be seen at this portion. Water quality and flow measurements were also done in this location as can be seen in the map.

Figure 13. Location of NIA office and NIS Structures in UPRIIS, Nueva Ecija



Sources: NAMRIA; NIA; DA BAR Metadata

5.1.2. Magat River Integrated Irrigation System (MARIIS)

In this system, the team has taken into consideration Division 2 and Division 4. For the Division 2, earth canals were observed to be damaged by carabaos when they dip in the water. This eventually causes siltation. Actually, the main source of siltation is the watershed. In the soil erosion map shown in Figure 15, moderate to severe erosion could be observed in the watershed area of MARIIS. Watershed area is the left and lower side part of Figure. Earth canals were also eroded by water flow (Photo 26). Lateral canals need to be rehabilitated. Earth canals (Photo 27) have to be lined. In MARIIS, the main canal has a length of 381 km while the total length of laterals and sub-laterals is 1,114 km. Not only the canals need rehabilitation but also the structures. Photos 28 to 30 show the current state of the structures in MARIIS. Most of the structures are damaged and deteriorating. The headgates in MARIIS is about 380 while the turnouts total to about 4,329.

The FUSA of MARIIS is about 85,731 has. The performance of MARIIS is presented in Tables 15 and 16. The performance of MARIIS-Division II is presented in Table 17. To improve the performance of the system, MARIIS is maximizing the available water resources by installing re-use dams (Photos 31 and 32) and pumping stations. Pumping stations in MARIIS includes MARIIS DIV IV PUMP 1 (No. of Pump units = 3; Pump Capacity = 69 cu.m./min; Service Area = 661 has); MARIIS DIV III PUMP 2 (No. of Pump units = 5; Pump Capacity = 199.2 cu.m./min; Service Area = 2,704 has); and MARIIS DIV III PUMP 3 (No. of Pump units = 5; Pump Capacity = 88.8 cu.m./min; Service Area = 2,885 has).

Another notable observation in MARIIS is the installation of a hydro power plant (Photo 33) along Lateral B, Division II, and MARIIS. Feasibility studies for the installation of hydro power plant in other Laterals of MARIIS as well as in UPRIIS are being prepared.

Table 15. Irrigated area of MARIIS from 2010 to 2014

PARTICULAR	2010	2011	2012	2013	2014
DRY	77,606	79,048	79,433	81,492	82,475
WET	78,769	80,192	79,815	81,791	79,853

Source: MARIIS, 2015

Table 16. Performance of MARIIS from 1999 to 2014

PARTICULARS		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cropping Intensity	Annual, %	186	175	180	173	172	175	178	179	178	182	203	184	194	212	226	215
Collection Efficiency	Annual, %	62	68	89	68	70	100	93	71	83	65	79	90	83	84	91	96
Average Yield	m.t. / ha	4.33	4.50	4.29	4.42	4.38	4.58	4.78	4.26	4.70	4.63	4.33	4.15	4.65	5.21	5.35	5.77
Viability Index	Annual	1.24	1.26	1.33	1.16	1.24	1.22	1.33	1.19	1.29	1.53	1.54	1.28	1.37	1.54	1.68	2.04

Source: MARIIS, 2015

Table 17. Performance of Division II, MARIIS from 2009 to 2014

CALENDAR YEAR	**CROPPING** SEASON	**IRRIGATED** AREA (ha.)	**BENEFITED** AREA (ha.)	**C.I.** (%)	**V.I.** (%)	**C.E.** (%)	**AVE. YIELD** (cav./ha.)
2014	Dry	23,560	22,505	195	1.71	93	116
	Wet	23,568	22,431				110

CALENDAR YEAR	CROPPING SEASON	IRRIGATED AREA (ha.)	BENEFITED AREA (ha.)	C.I. (%)	V.I. (%)	C.E. (%)	AVE. YIELD (cav./ha.)
2013	Dry	23,149	23,038	194	1.62	89	110
	Wet	23,258	23,065				109
2012	Dry	23,105	23,105	193	1.28	87	111
	Wet	23,105	23,105				109
2011	Dry	23,118	22,678	195	1.39	73	112
	Wet	23,118	16,622				82
2010	Dry	22,676	13,807	200	1.03	86	75
	Wet	22,812	13,118				110
2009	Dry	22,474	22,474	198	2.15	81	95
	Wet	22,474	21,390				87

Photo 26. Unlined section of Lateral B, Div. 2, MARIIS with damages from erosion

Photo 27. Unlined canal of Lateral B, Division II, MARIIS

Photo 28. Damaged structures along Lateral D2, Div.4, MARIIS

Photo 29. Damaged canal and turnout in a section Lateral Dw-D, Div.4, MARIIS.
Take note that the Lateral was unlined

Photo 30. Control and division structures along Lateral B, Div.2, MARIIS.
Take note of the damages and condition of the canal and structures.

Photo 31. Check gate of Palomares Diversion Dam.
One of the re-use dam in Div. 2, MARIIS.

Photo 32. Main canal of Nungnungan Dam (re-use dam), Div.4, MARIIS.

Photo 33. Mini-hydro power plant (45kW) along Lateral B, Div. 2, MARIIS.

The DEM map, soil erosion map, slope map, built-up area map and overlaid maps of MARIIS are shown in Figures 14 to 22. The overlaid maps show the reduction in service area in terms of the different component maps. The overlaid maps show the reduction in service area in terms of the different component maps. From the Erosion Map, the delineated FUSA was overlaid to determine the erodibility of the soil within the FUSA. These show reduction in FUSA by 16% in terms of the erodibility of the soil alone. In Figure 17, the Map of Major Built-up areas are shown as digitized from Google Earth image (as of 2015). The slope derived from remotely sensed DEM image is cropped by the delineated FUSA and the resulting map show a reduction in service area by 6% for MARIIS. The soil type map from BSWM Reconnaissance Survey obtained by DA-BAR was incorporated in the FUSA show a reduction in service area by 26%.

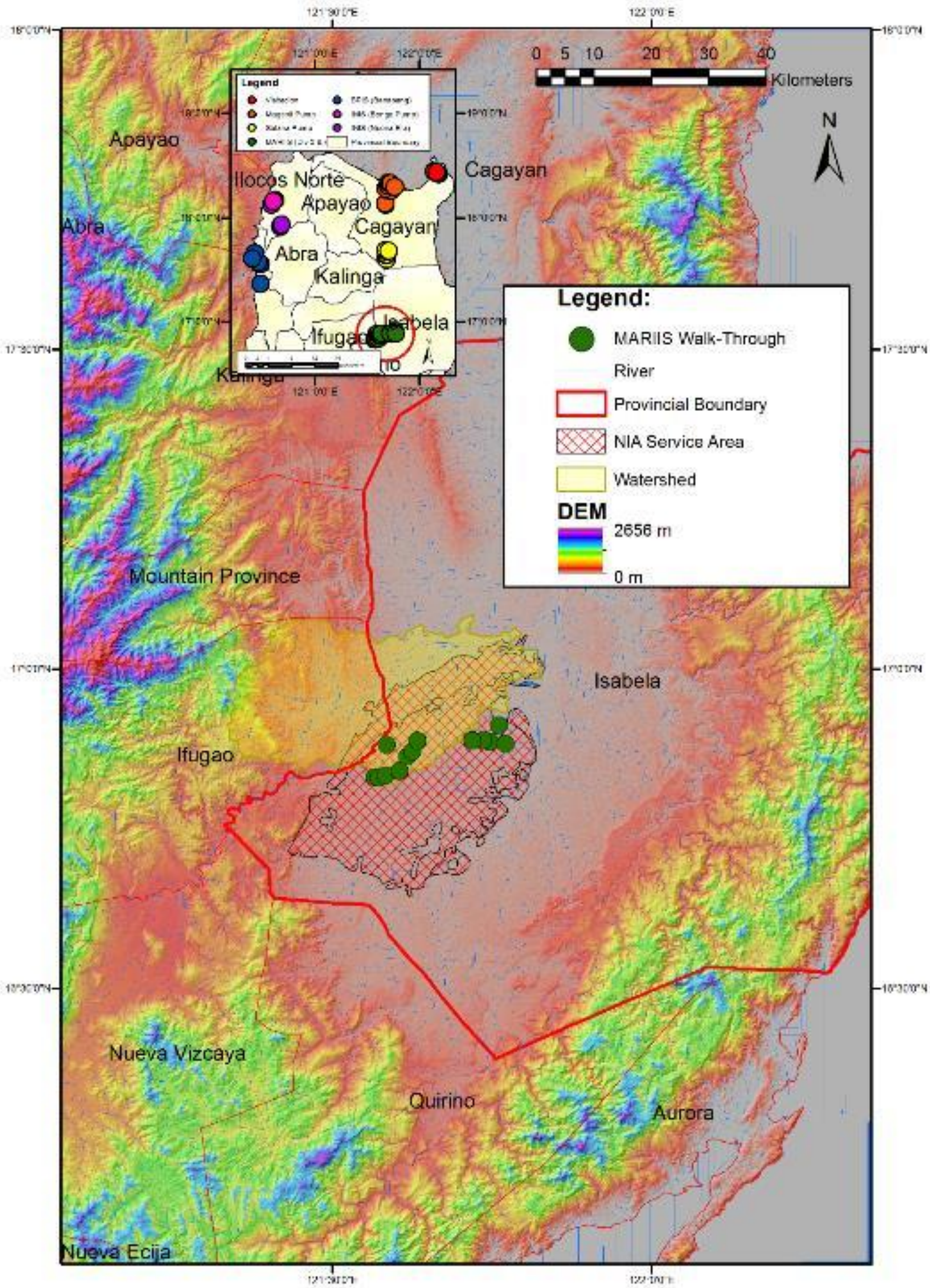
Using these 4 individual maps (erosion, slope, soil type, and built-up areas) with values showing desirable vs undesirable properties, they were overlaid using the Map Algebra function of GIS incorporating the 'Boolean' algebra, this resulted to final overlaid map as shown in Figures 21 and 22 for MARIIS. The reduction in the service area is 46%. This result just implies that only 54% of the total FUSA for MARIIS is just available for farming which may result to optimum yield given a favorable condition. But this doesn't imply that you can no longer use the undesirable FUSA. This may just help to explain why some farmers obtain unfavorable crop yields.

Table 18. Performance indicator for MARIIS

PERFORMANCE INDICATORS	DIVISION I *(10-year data)*		DIVISION II *(10-year data)*		DIVISION III *(11-year data)*		DIVISION IV *(6-year data)*	
	Dry Season	*Wet Season*	*Dry Season*	*Wet Season*	*Dry Season*	*Wet Season*	*Dry Season*	*Wet Season*
Relative Water Supply [RWS][1] *(m^3/m^3)*	0.41	.52	0.66	0.81	0.51	0.82	0.49	0.59
Irrigated Area Performance [F][2]*(%)*	88.49	83.07	93.91	93.93	76.51	70.31	91.2	91.23
Gross Irrigation Water Quota [M][3] (m^3/Ha)	17,521	13,466	29,477	30,350	21,270	29,481	17, 012	17, 001
Yield Per Unit Area [Y][4] (kg/Ha)	4,664	4,416	4,969	4,386	5,450	5,250	4,358	3,883
Yield per unit Quantity of Irrigation water [Yw][5] (kg/ m^3)	0.28	0.28	0.17	0.15	0.24	0.16	0.26	0.23

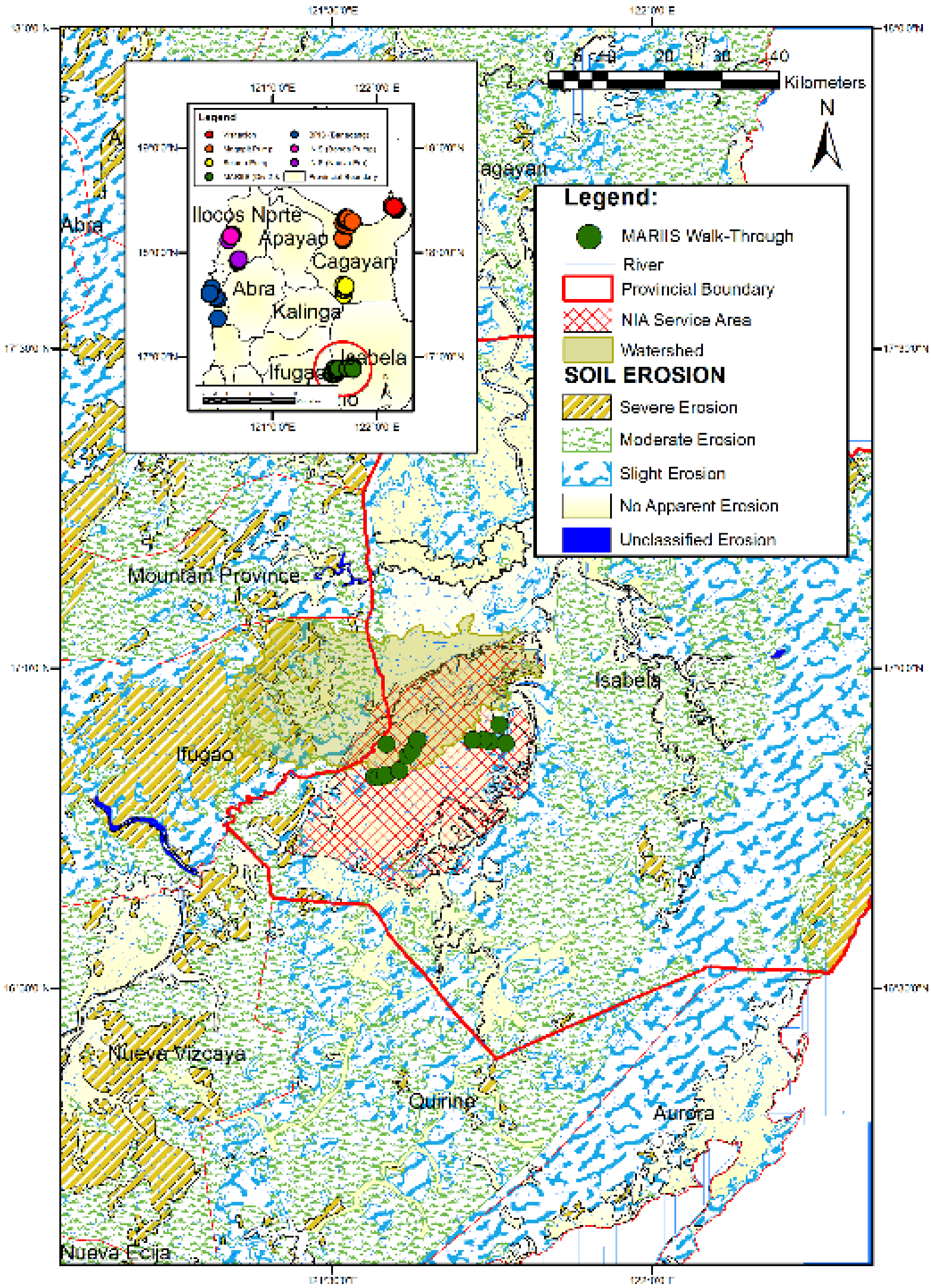
(Source: DOST NUWAM Project)

Figure 14. DEM of MARIIS, Isabela



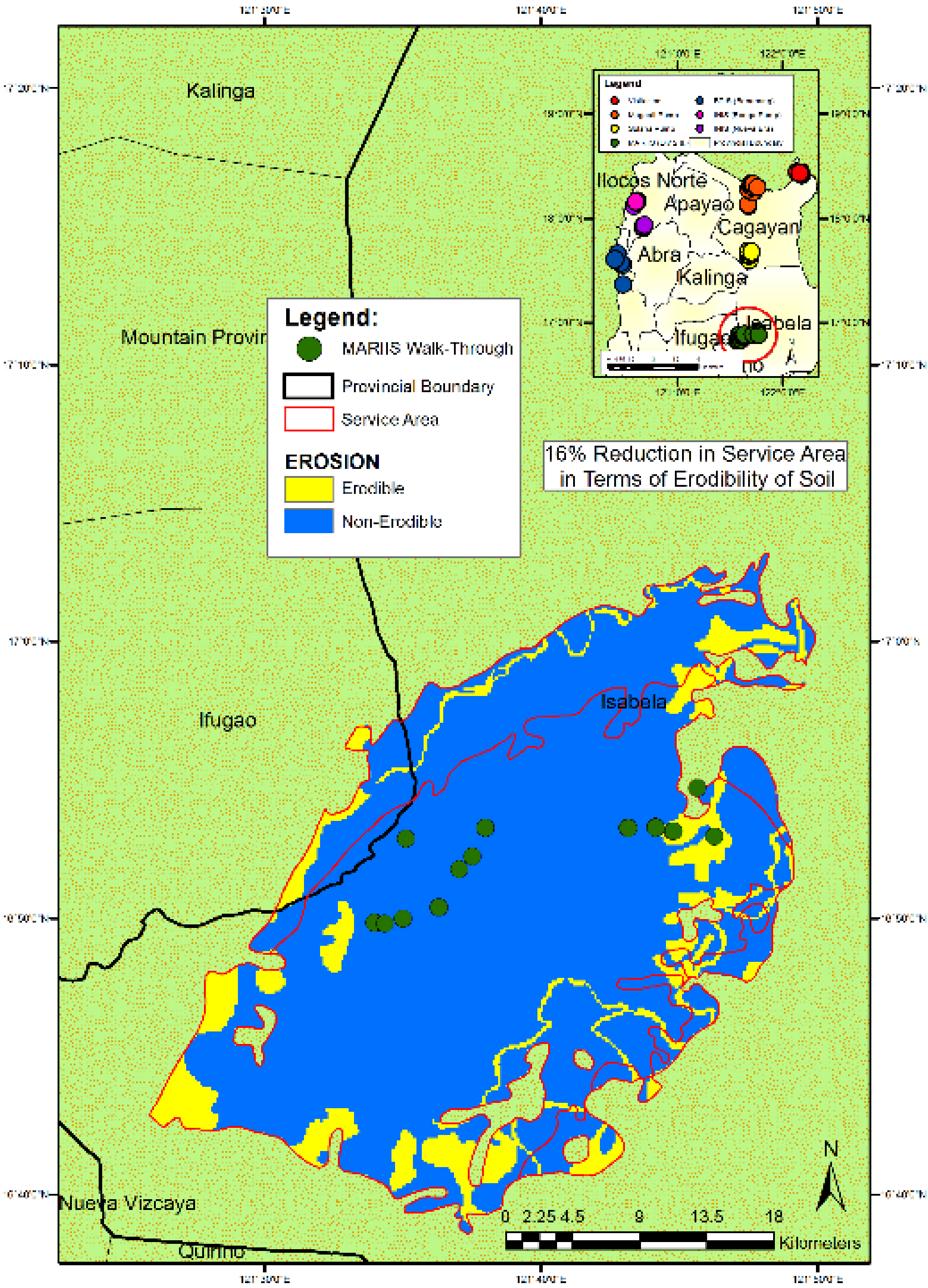
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 15. Soil erosion map of MARIIS, Isabela



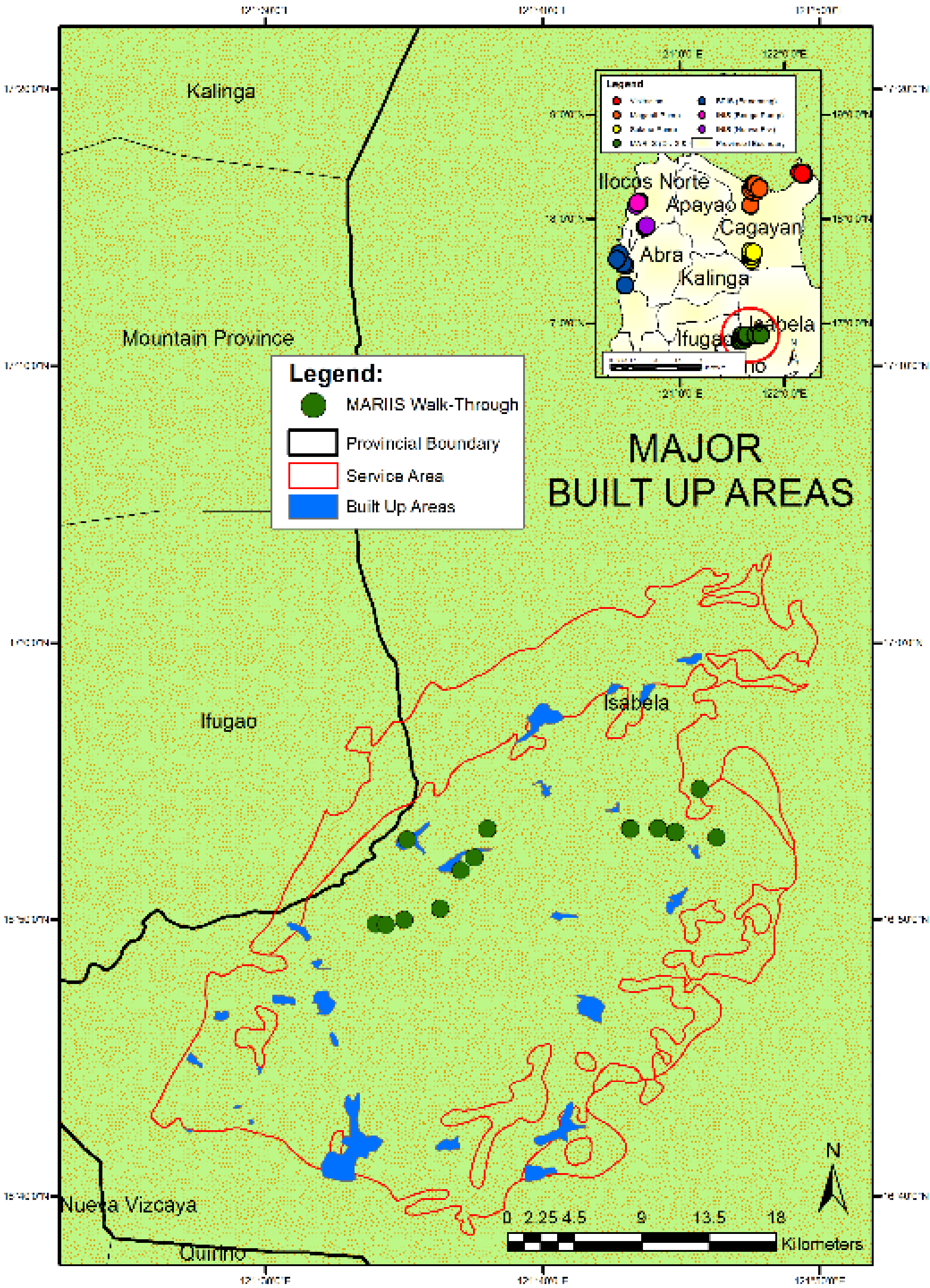
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 16. Overlaid map of MARIIS, Isabela showing reduction in service area in terms of erodibility of soil



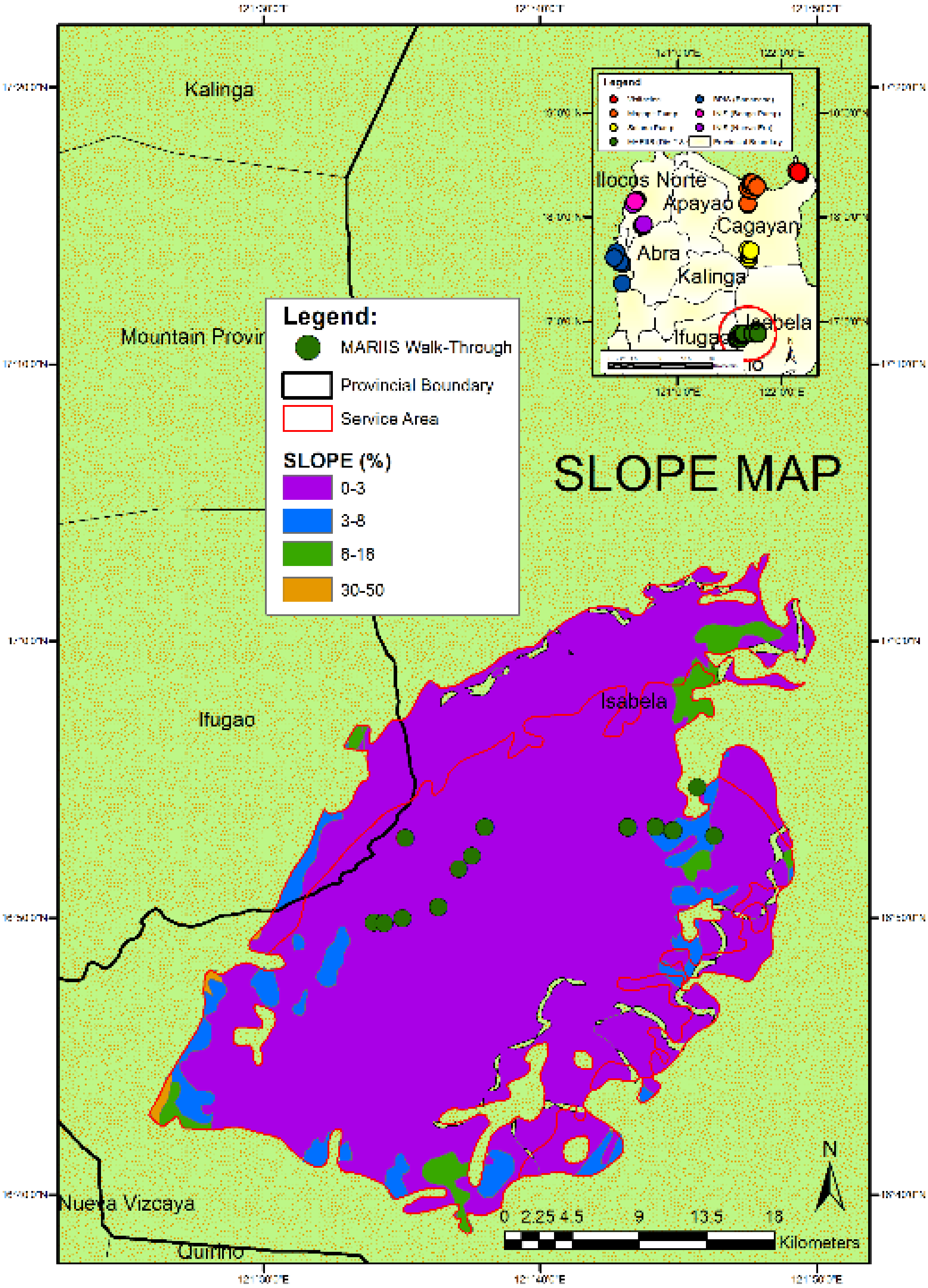
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 17. Built-up area map of MARIIS, Isabela



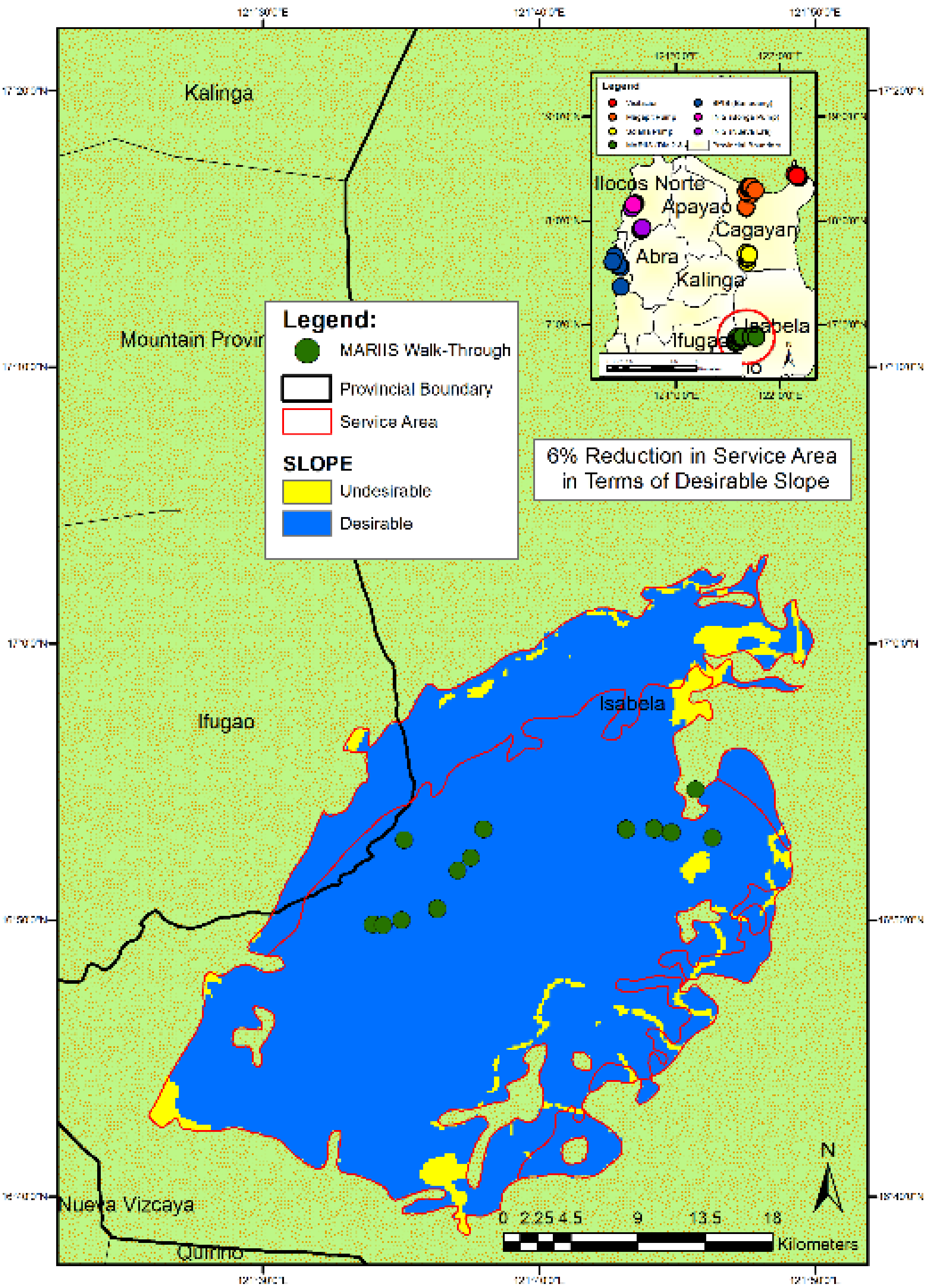
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 18. Slope map of MARIIS, Isabela



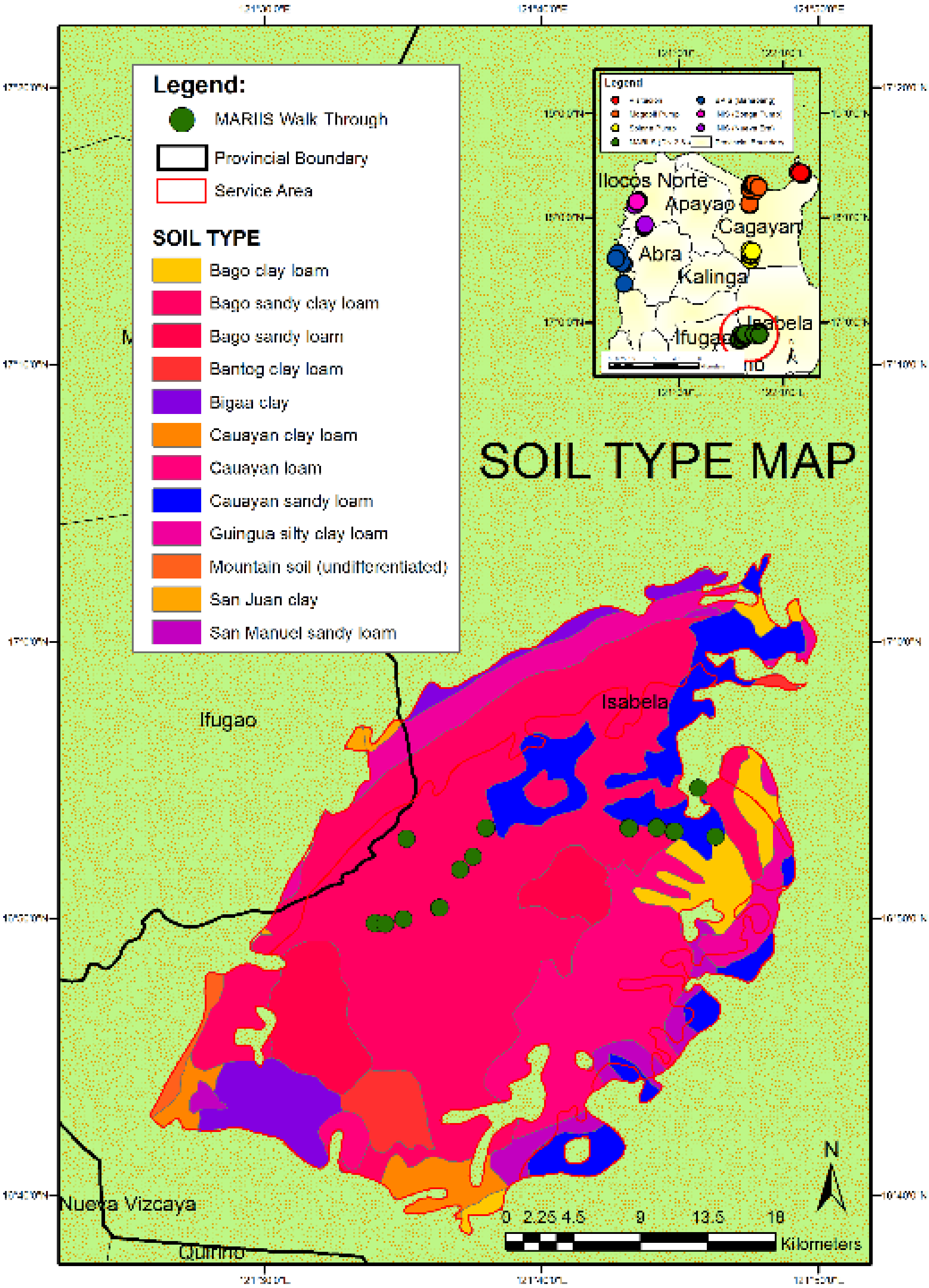
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 19. Overlaid map of MARIIS, Isabela showing reduction in service area in terms of desirable slope



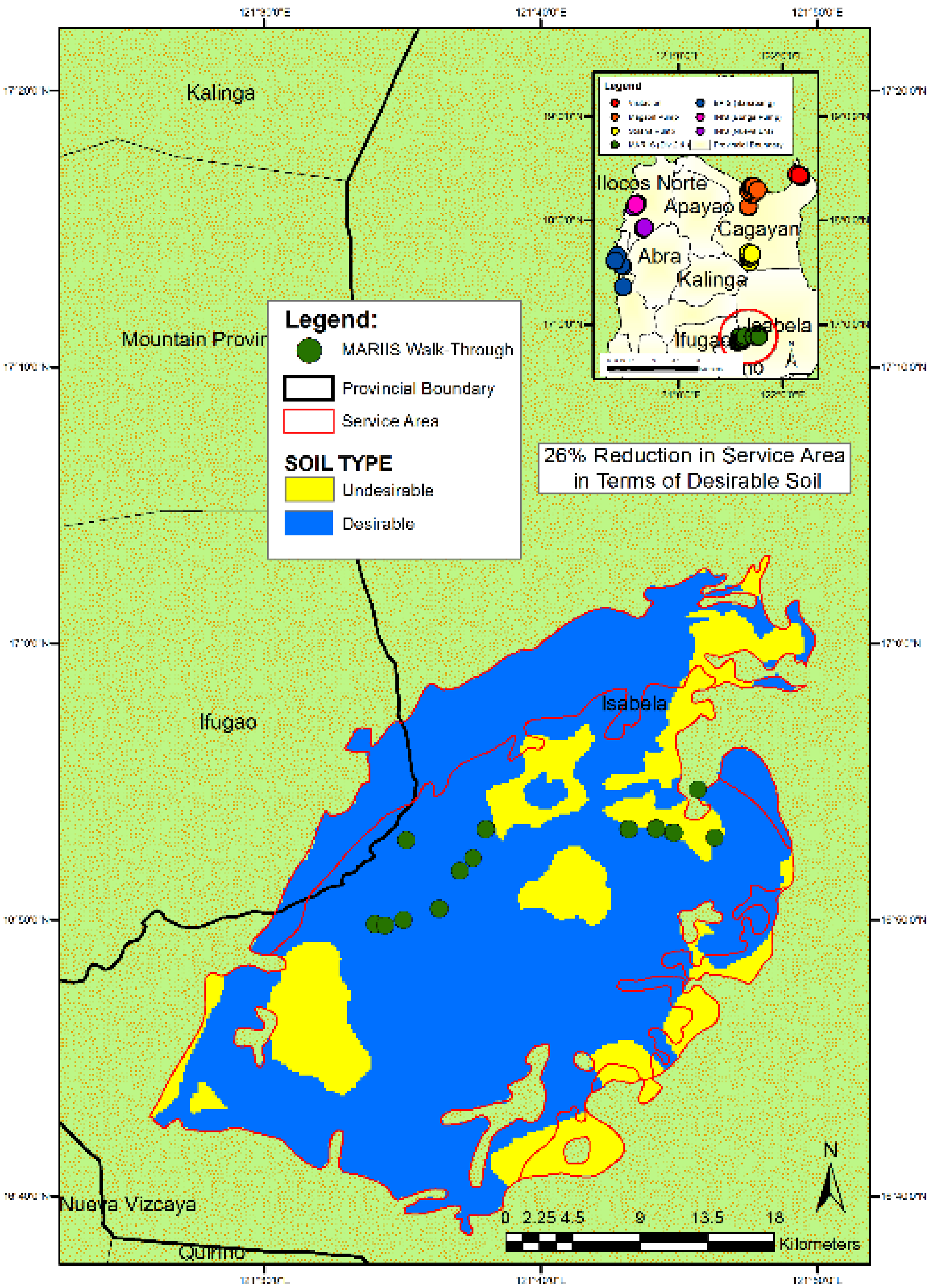
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 20. Soil map of MARIIS, Isabela



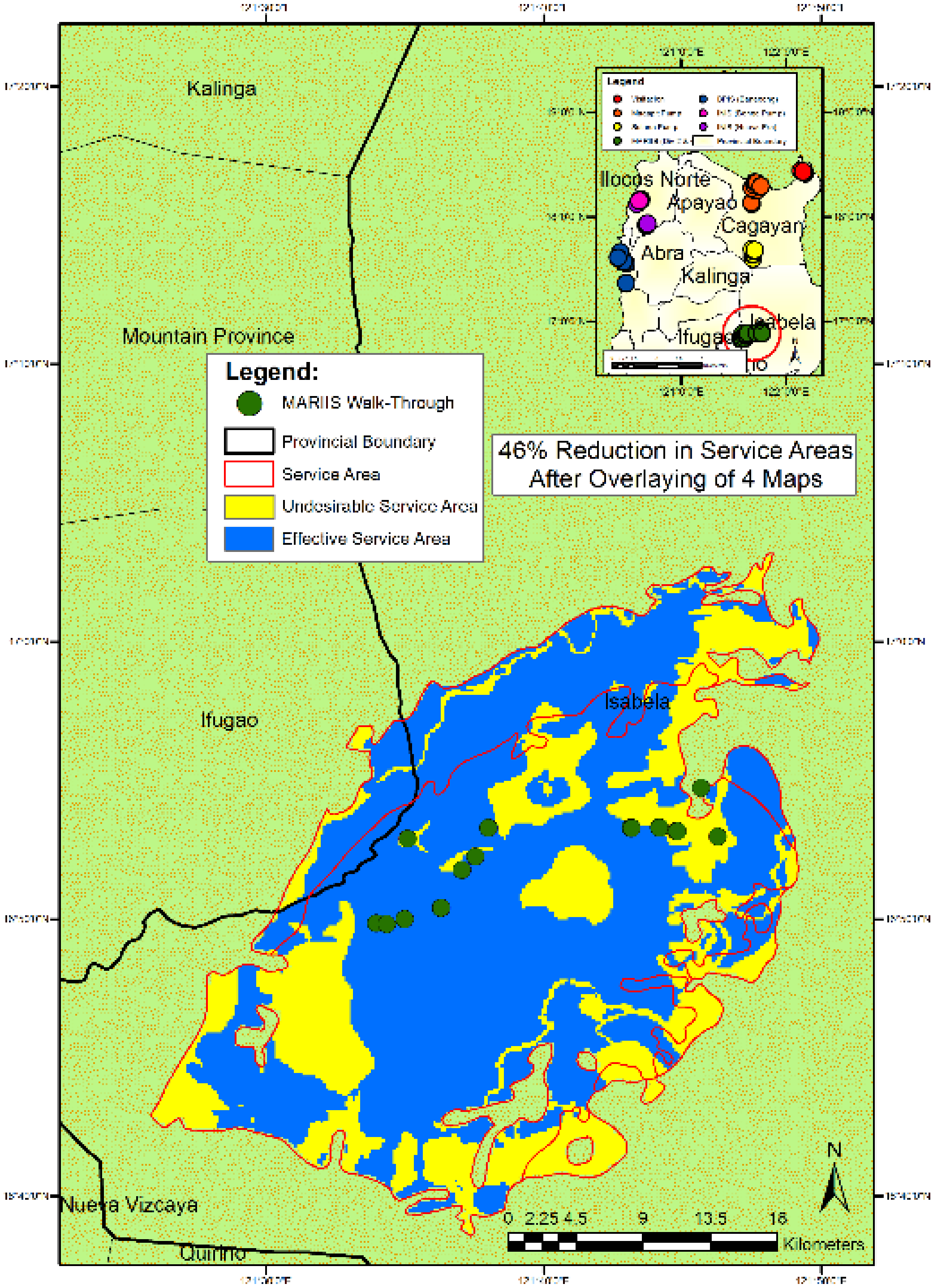
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 21. Overlaid map of MARIIS, Isabela showing reduction in service area in terms of desirable soil



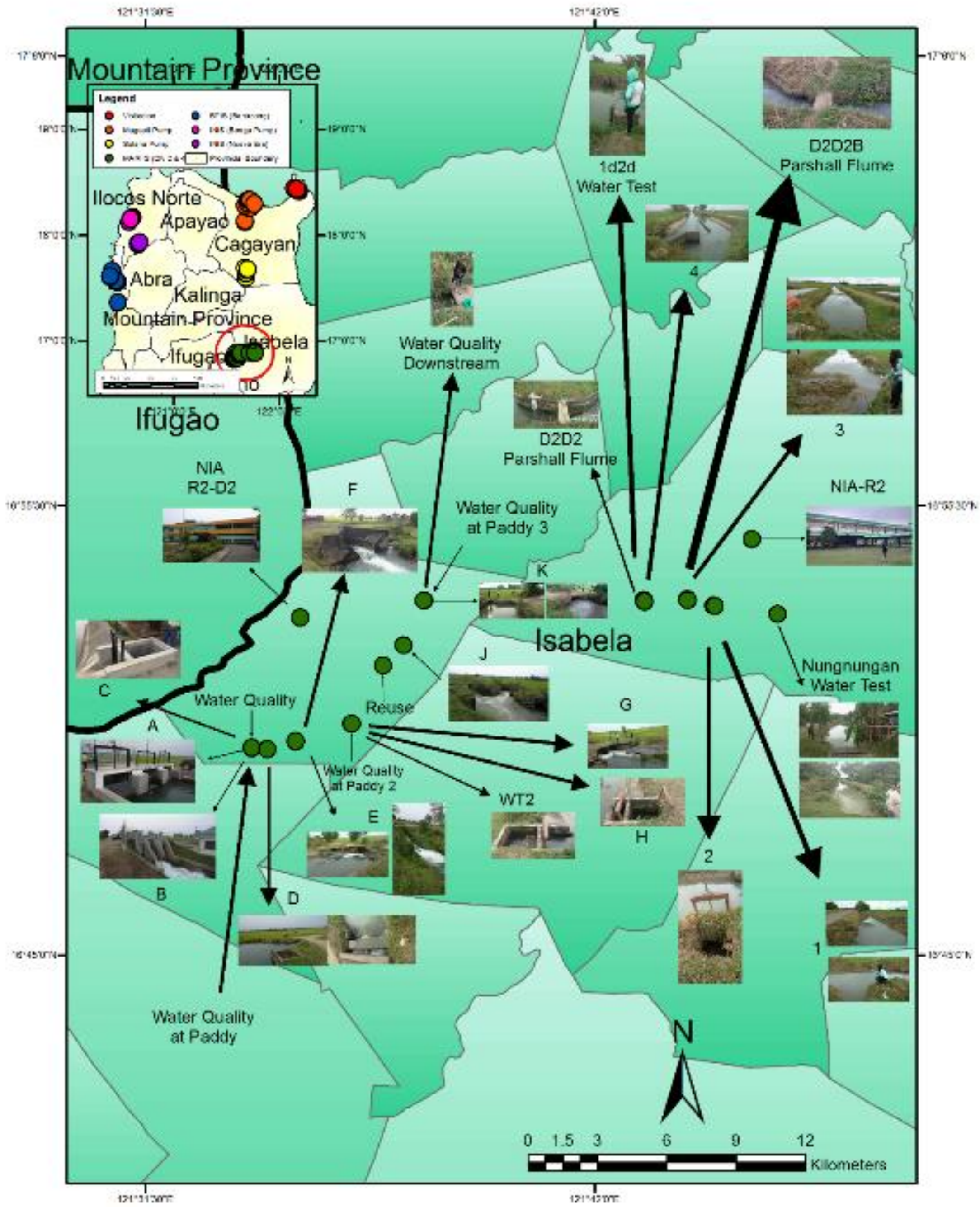
Sources: NAMRIA; NIA; DA BAR Metadata

Figure 22. Overlaid map of MARIIS, Isabela showing reduction in service area



Sources: NAMRIA; NIA; DA BAR Metadata

Figure 23. Location of NIA office and structures in MARIIS, Isabela



Sources: NAMRIA; NIA; DA BAR Metadata

Figure 23 shows the actual NIS walkthroughs for MARIIS. Different irrigation structures together with measurements on canal flow and water quality can also be seen in this Figure.

Table 19. Summary of Technical, Institutional and Environmental issues confronting the representative NIS in Luzon (i.e. UPRIIS, Pampanga and MARIIS, Isabela)

	Technical Issues	Institutional Issues	Environmental Issues
Pampanga	Most laterals are earth canals	Experienced pest infestation in 2013 due to 5 in 2	Water quality measurements or information are lacking in all NIS cases visited.
	There is double pumping of water from drainage (Pump operating cost is PhP 3,000 per ha	Farmers only get break-even thus cannot pay the ISF	
	Need to improve irrigation facilities (e.g. turnout gates)	Conflict arises due to difficulty in convincing other members to pay the ISF	Measured water quality in the downstream part of PIDRIS showed low DO levels of 2.7 ppm.
	Rehabilitation of damaged canals	NIA has no adequate funds for major repair and rehabilitation	pH values are greater than 7 which is above neutral and little bit alkaline.
	Main canal of PDRIS is already highly silted, around 40%, due to lahar	Reshuffling of management affects prioritization of programs which leads to delay or cancellation	However, the other parameters like EC is not a concern.
	Silt levels were measured to be around 10 cm- 41 cm	Conflict arises due to difficulty in convincing other members to pay the ISF	
		Illegal pumping and garbage dumping	
Nueva Ecija (Division 2)	Target improvements are: to restore approximately 100 hectares in addition; modify check structures; improve canal linings to reduce losses	Previously, support from NIA is very good. However, it drastically decreased as of 2006 because of cost cutting measures followed by RAT Plan	The lateral downstream of Vacca Dam exhibited very low DO of 1.1 ppm. This can be attributed to the thick aquatic vegetation just upstream of the Vacca dam which caused the low DO downstream.
	Some members use surface pumps which increases their cost from P3000 – P5000 (per ha)	Usual conflict is due to distribution of water	pH values are greater than 7 which is above neutral and little bit alkaline

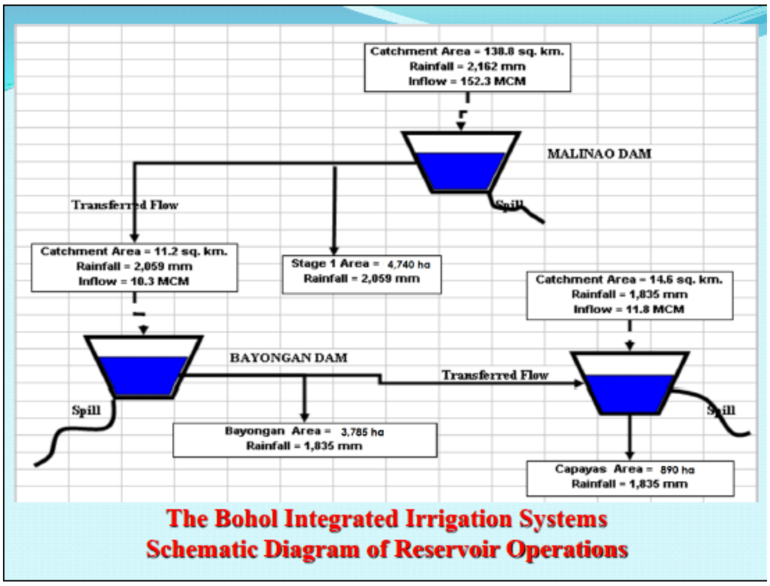
	Technical Issues	Institutional Issues	Environmental Issues
	LTRIS dam damaged due to typhoon Mario	High prevailing prices of inputs while selling prices of harvest is low	However ,the other parameters like EC is not a concern.
Division 4	Earth canals are very prone to damage and siltation	Weak policy enforcement on informal settlers	No water quality data since measurement or water quality monitoring is not done
	Declining water supply due to heavy siltation of Peñaranda river	Initially, the IA constructed brush dams in order to store water. However, due to a dike construction by the DPWH, the water that flows to the brush dam and eventually to the canal is blocked.	Measured pH values are greater than 7 which is above neutral and little bit alkaline.
	Heavy siltation is due to poor watershed management		However, the other parameters like EC and DO are not a concern.
	Water source is too far (Pantabangan dam), thus even if the dam is full, water has to travel a very long distance before it reaches the division		No water quality data since measurement or water quality monitoring is not done
	Highly recommend continuing the proposed Balintingol dam where it could store water near Division 4 area		

Table 19 summarizes the issues/concerns observed in UPRIIS and MARIIS. The technical problem is mainly due to siltation of canals especially the unlined canals which further contributes to the poor water distribution especially in the downstream part of the main canal. The Institutional issue revolves on weak enforcement of policies with regards to illegal settlers/pumping/garbage dumping, conflicts due to ISF collection and water distribution, high costs of inputs, etc. The environmental concerns is due to poor water quality as reflected in low DO and high pH, which could have affected the yield in those NIS. High EC was also reported in other NIS in Luzon especially those pumping saline groundwater (Please see section on water quality).

5.1.3. Malinao IS

The three (3) NIS visited in Bohol was part of the Bohol Integrated Irrigation System. It consists of three (3) reservoir-type dam system namely: Malinao IS, Bayongan IS and Capayas IS. Because of the very small catchment area of Bayongan reservoir (11.2 sq.km.) most of its water supply will come from Malinao reservoir. It was estimated that about 63.5 MCM of water per year will be transferred from Malinao reservoir to Bayongan reservoir thru Malinao Main Canal (Figure 24). At km. 16+880 Malinao main canal, a spillway structure (Photo 34) was constructed and connected to a chute which diverted and convey water down to Bayongan reservoir located at an elevation approximately 100 meters below with a gross capacity of 34.6 MCM. Malinao dam supplies water to Bayongan if dam water level is 151.6 m and above. Bayongan reservoir transfer water to Capayas reservoir through a supply canal only if the water is in excess.

Figure 24. Schematics of the water transfer from Malinao down to Capayas reservoir.



(Source: NIA Region 7)

Figure 25. 3D map showing the area around the Malinao, Capayas and Bayongan IS.

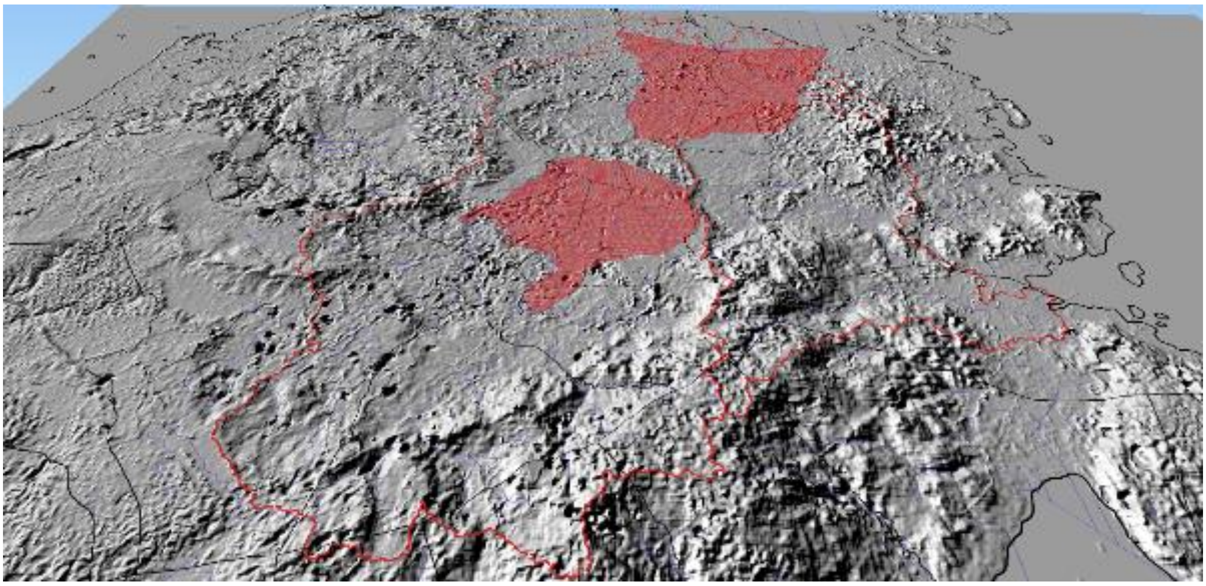


Photo 34. Gate of the spillway that supply water to Malinao IS to Bayongan reservoir

Cropping intensities of the systems under the Bohol Integrated Irrigation System was relatively low as presented in Table 20. The highest cropping intensity for Malinao IS was the year 2017 while the Bayongan IS has the highest during the year 2017. The highest cropping intensity for Capayas IS was also the year 2017 and it has also the lowest cropping intensity among the three systems.

The Malinao IS is supplied by water from Malinao Dam which is located in the southeastern part of Bohol in the municipality of Pilar. It is a reservoir-type dam that covers the municipalities of Pilar, Alicia, SanMiguel, Dagohoy and Ubay with a total service area of 4,960 hectares with the Wahig and Pamacsalan Rivers as the water sources. It was implemented by the National Irrigation Administration (NIA) from February 1,1984 to December 31,1997 with a total project cost of P1,565,264,141.00 which was assisted by the Japan International Cooperation Agency (JICA).

There were about 50 direct turnouts from the Main canal (Photo 35). The system allowed pumping (Photo 36) from the main canal, on the right side. Schedule of pumping depends on their location. It was mentioned that siltation could be observed in some downstream sections but minimal. It could be flushed out during high flow but was not documented during the visit.

Table 20. Cropping intensity of Bohol NIS from 2014 to dry season, 2018

Name of System	CY 2017		PLANTED AREA																
			2014				2015			2016			2017				2018		
	FUSA	Optimal Area	WS	DS	Ratoon	CI	WS	DS	CI	WS	DS	CI	WS	DS	Ratoon	CI	WS	DS	CI
Malinao IS	4,740	3,866	3,149	3,108	650	146	2,742	3,300	127	3,167	2,442	118	3,831	3,662	1,250	185	227	4,011	89
Bayongan IS	4,084	3,063	2,602	2,659	1,025	154	1,494	2,670	102	895	2,404	81	2,922	2,877	1,735	185	1,259	3,063	106
Capayas IS	1,113.1	858	592	596	93	105.91	71	588	54.49	68	435	41.6	694	746	480	158.7		858	77.1
Talibon IS	967.7	943	464	574	0	103.82	575	574	114.94	582	569	115.11	604	604	250	145.8		943	97.4
Total	10,905	8,730	6,807	6,937	1,768	140.59	4,882	7,132	108.88	4,712	5,850	95.73	8,051	7,889	3,715	178.1	1,486	8,875	95

Source: NIA Region 7

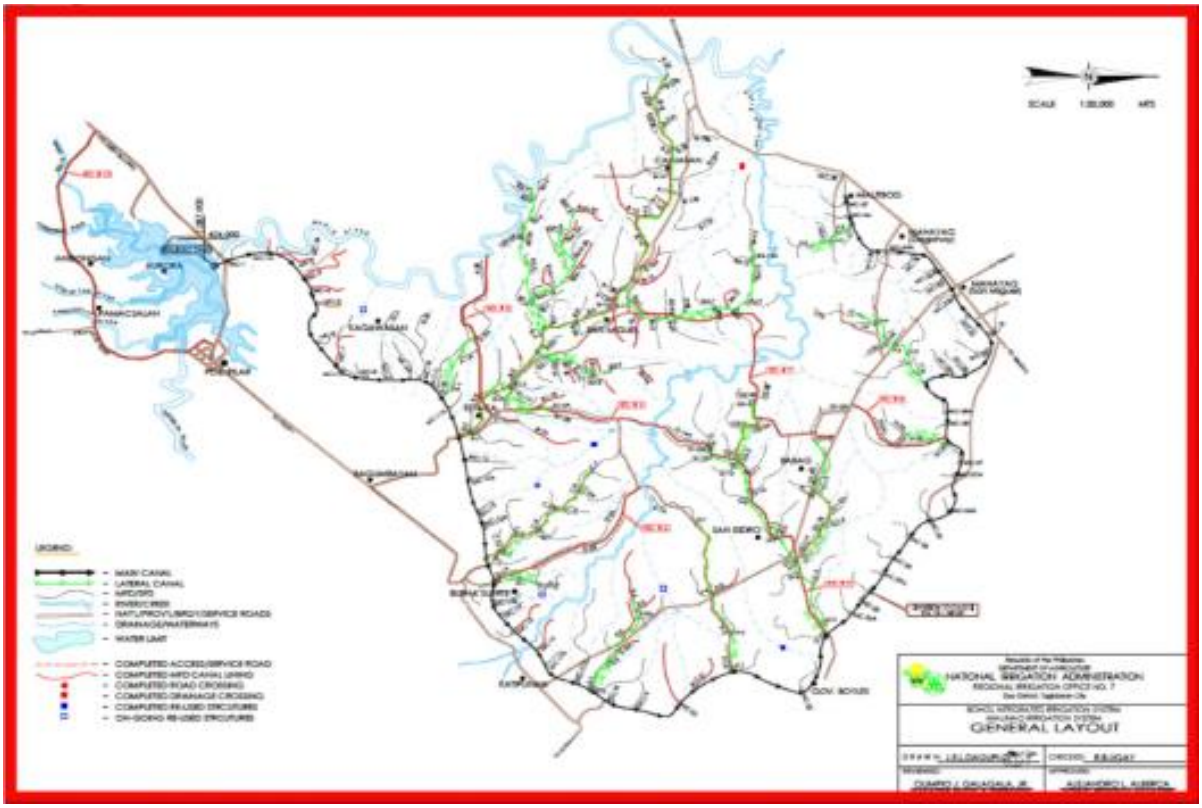
Photo 35. A direct turnout along MC of Malinao IS near Sta 0+00

Photo 36. A pumphouse along MC in the upstream section of Malinao IS.

Most of the Main and Lateral canals of the three systems are lined (Photo 37-41). Canal layout map of Malinao IS is presented in Figure 26.

Photo 37. Section of Lateral D, Malinao IS in the downstream that are lined.

Figure 26. Canal layout of the Malinao IS.



(Source: NIA Region 7)

Most of the Main and Lateral canals of the three systems were installed with staff gages for monitoring flow intakes (Photo 38). Same with NIS in Luzon some of the gates of systems in Bohol has padlock (Photo 39). Siltation in the canals came from roads along the canal. Debris from plants and trees in the area usually clogged the gates at the lateral and turn outs (Photo 40). There were also several damaged structures, one can be seen in Photo 41.

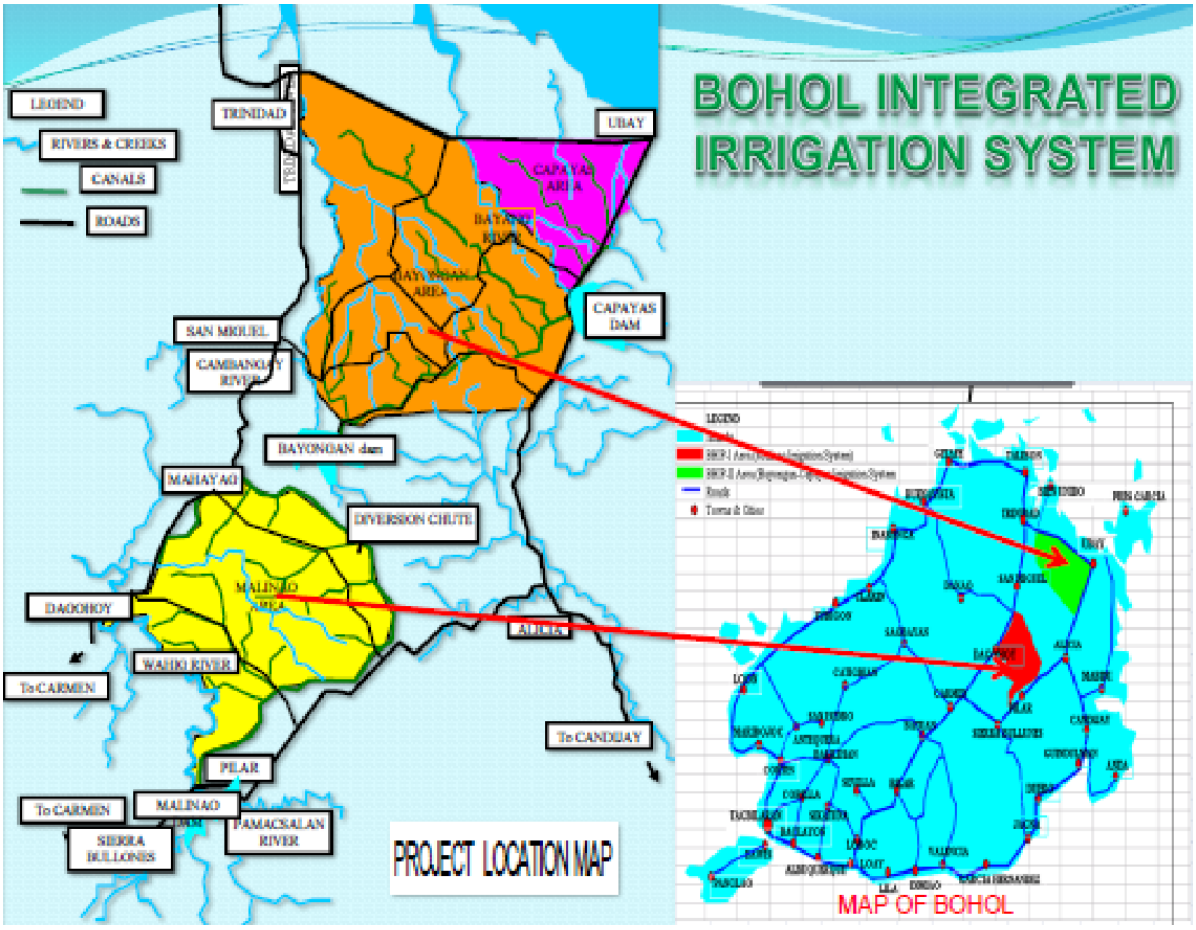
Photo 38. Staff gage installed in the downstream section of Malinao IS MC.

Photo 39. A gate with padlock in the downstream section of Malinao IS Lateral F.

Photo 40. Check gate at the downstream section of Lateral D, Malinao IS. Take note of the debris on both sides of the canal.

Photo 41. Damaged structure in Malinao IS.

Figure 27. Location map of the Bohol Integrated Irrigation System

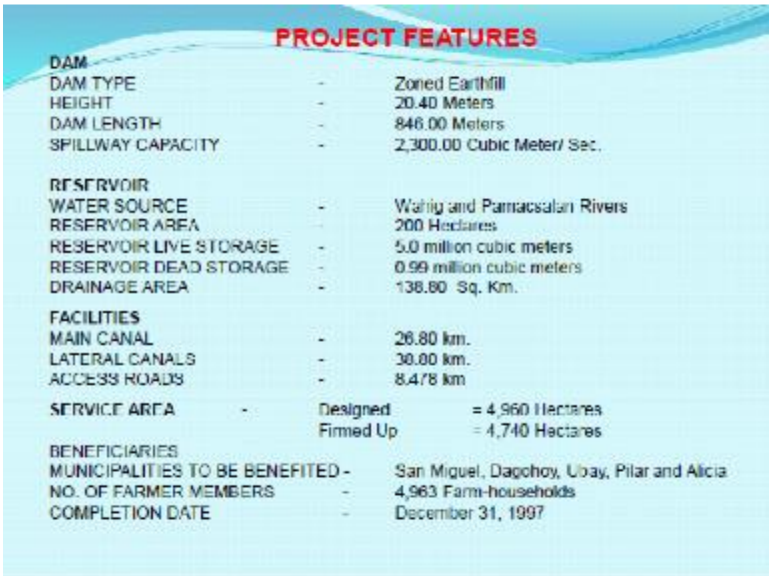


(Source: NIA Region 7)

Photo 42. Headwater of the Main Canal, Malinao IS.

Photo 43. Duckbill weir near Lateral A, Malinao IS.

Figure 28. Malinao dam profile.



(Source: NIA Region 7)

Figure 29. Bohol groundwater potential map.

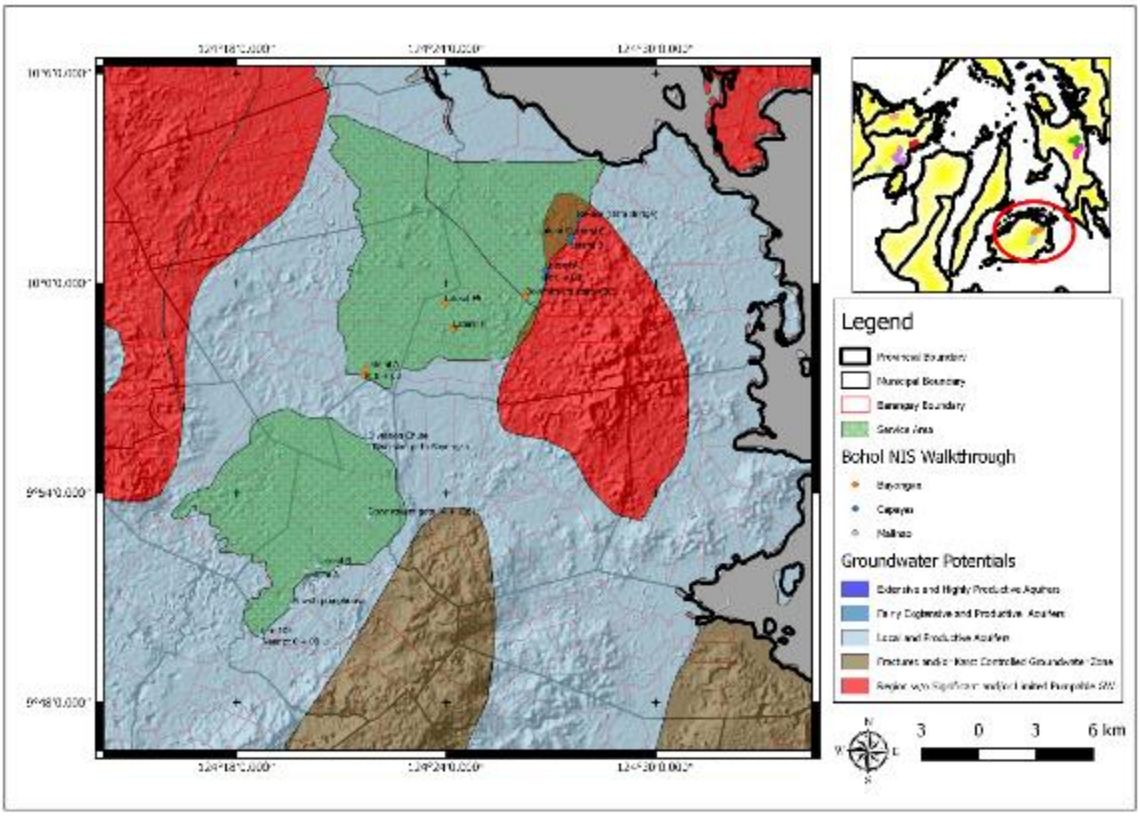


Figure 30. Bohol Erosion Map.

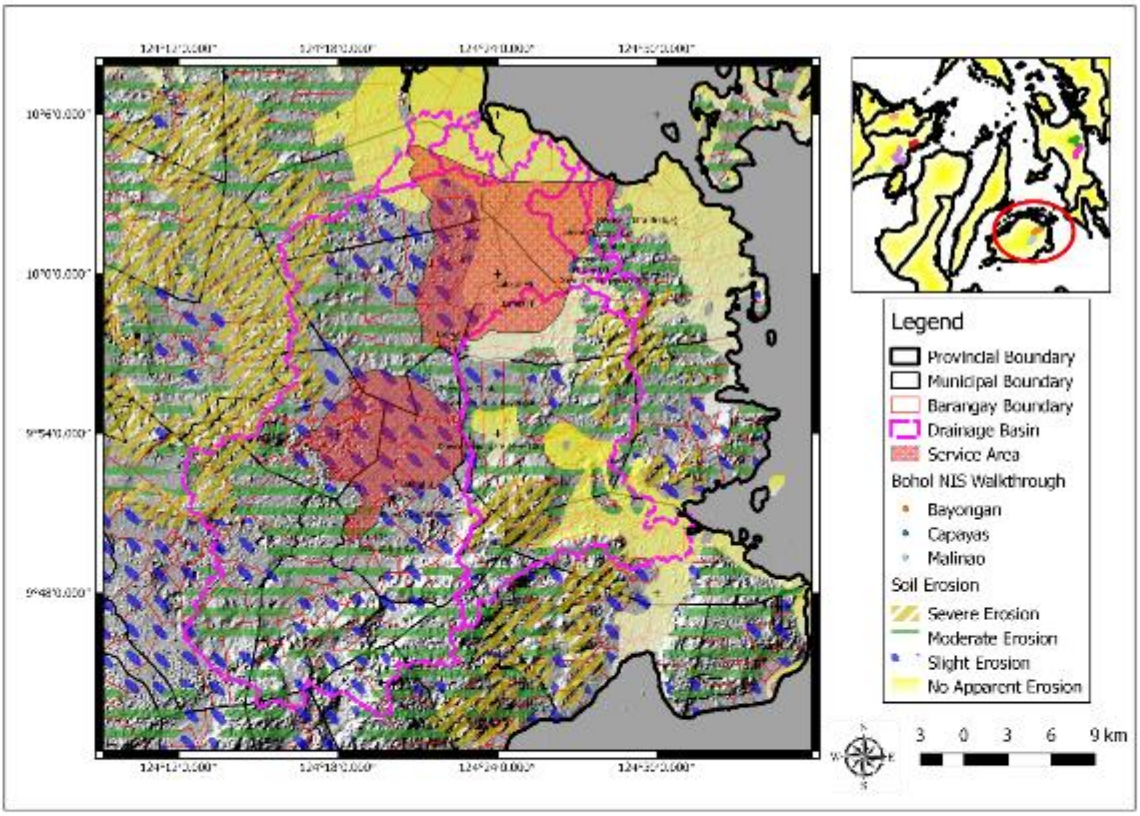
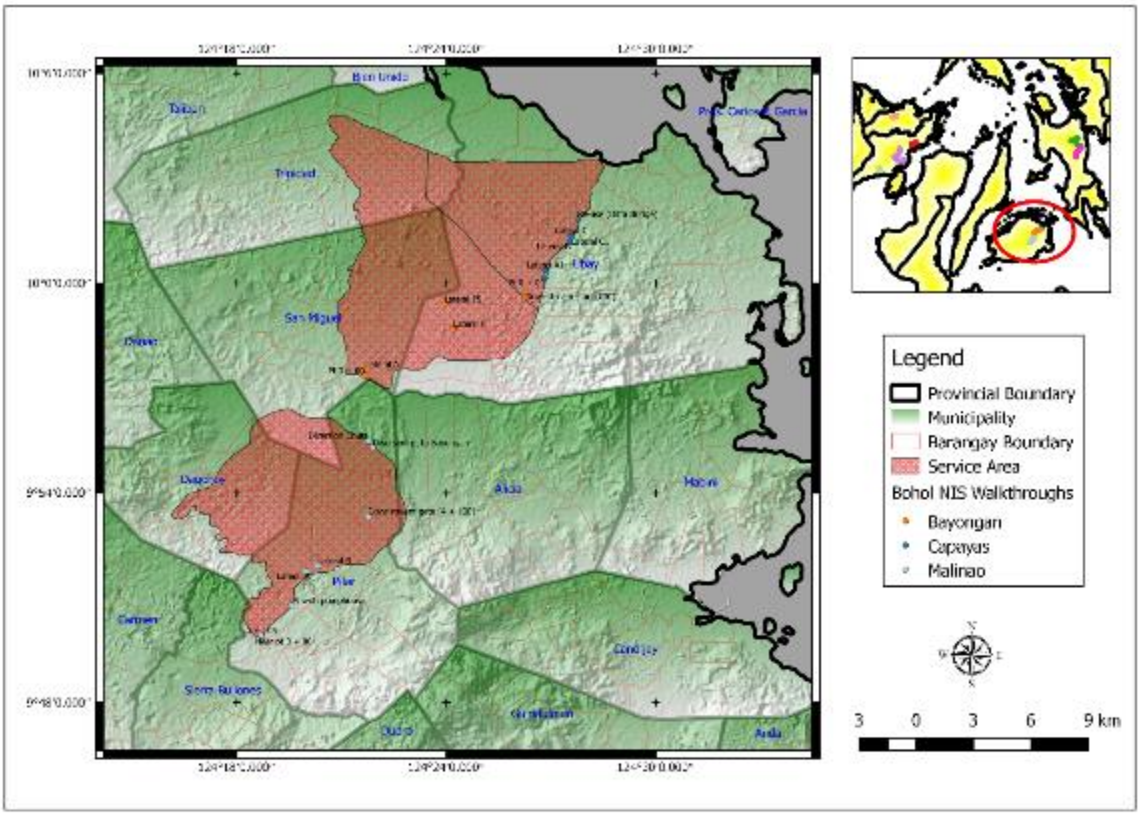


Figure 31. Bohol walkthroughs and system boundaries.



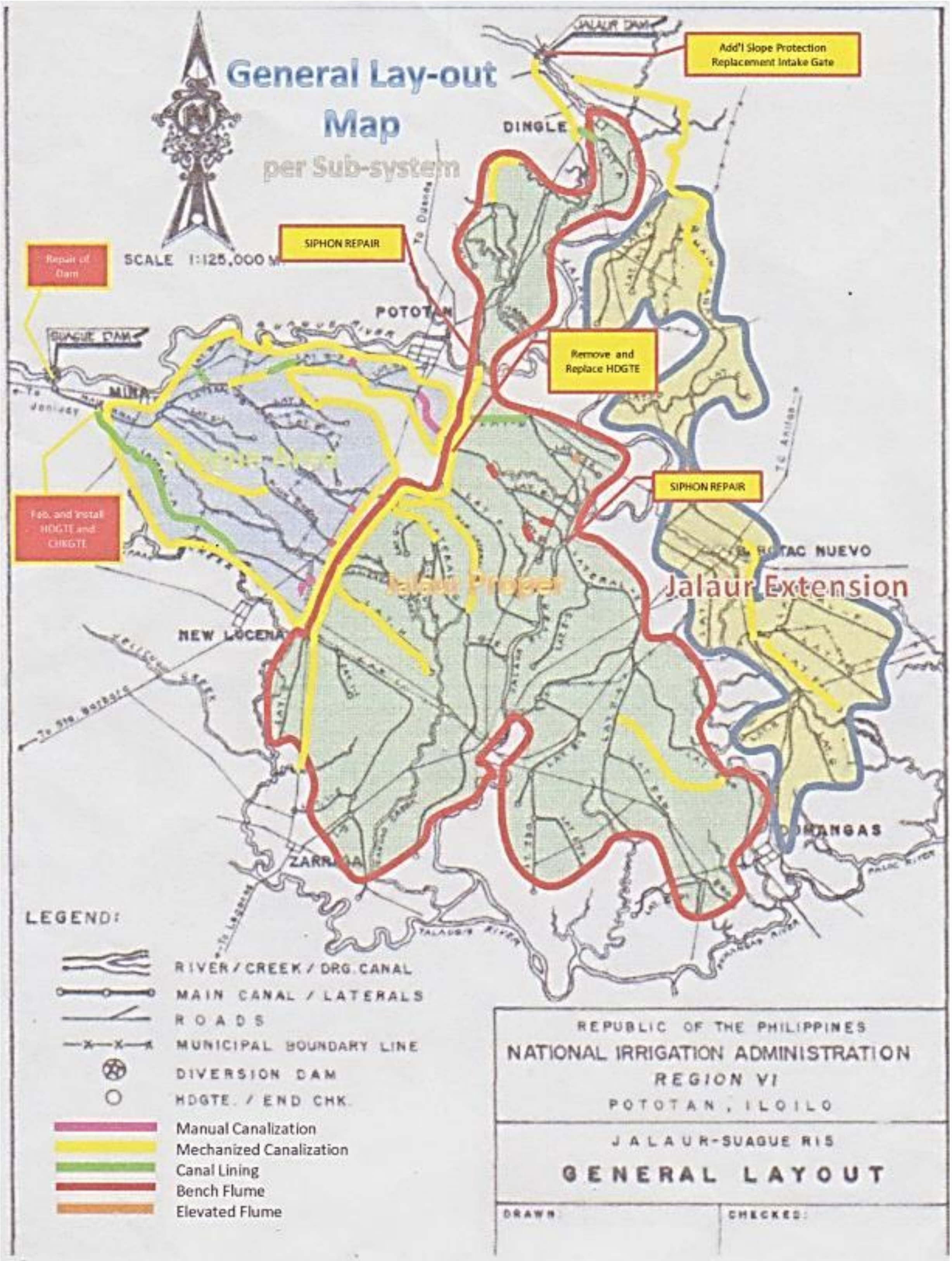
5.1.4. Jalaur-Suague RIS

In the Jalaur-Suague RIS, separate Main Canal supplies Jalaur Proper and Jalaur Extension (Photo 44) but only one source. Suague RIS has separate diversion dam and canal layout (Photo 46). Moreover, the main canal and Lateral B of Suague RIS is connected to the main canal of Jalaur Proper to augment water supply (Figure 45). One of the problems in the operation of Jalaur-Suague RIS is siltation in the canal as mentioned by the farmers and observed in the field (Photos 47 and 48).

Photo 44. Diversion dam of Jalaur Proper and Jalaur Extension RIS.

Photo 45. Dry log debris on the side of Jalaur-Suage RIS

Figure 32. General canal layout of the Jalaur-Suague RIS.



(Source: Iloilo-Guimaras IMO)

Figure 33. 3D map showing the Sibalom-Tigbauan, Jalaur-Suague, and Barotac Viejo RIS.

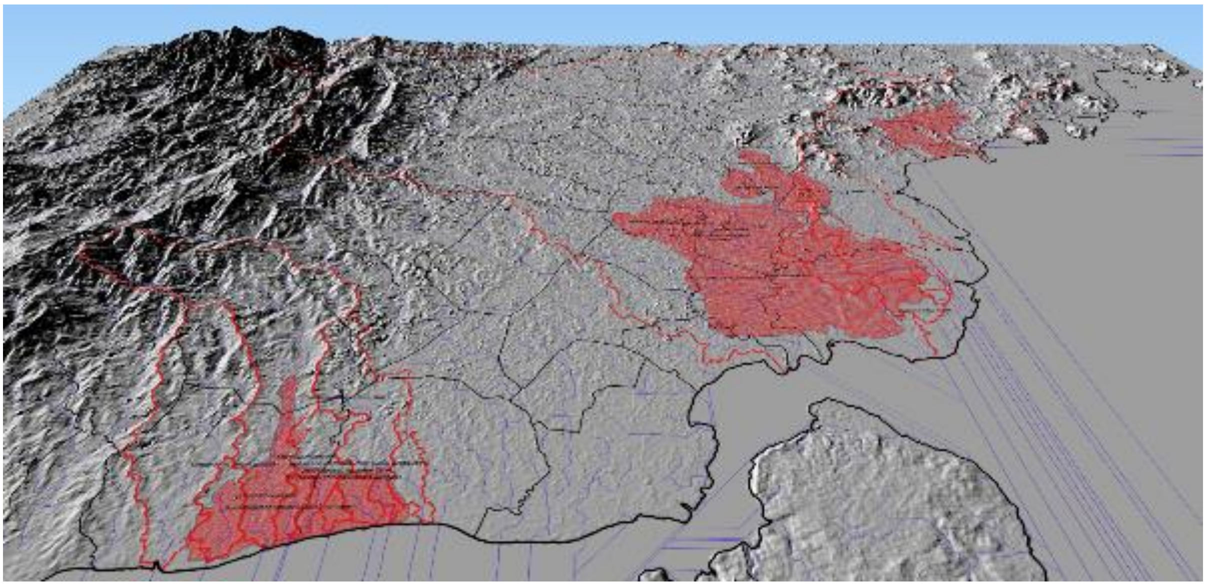


Photo 46. End section of the Main canal of Suague RIS that flows into the Main Canal of Jalaur Proper RIS. Take note of the pumpset on the right side.

Photo 47. Section of Jalaur Suage near the residential areas.

Photo 48. Silted section of Lateral C, Jalaur Proper RIS near the headgate.

Photo 49. Clogged canal in Sibalom Tigbauan.
(Take note of the dead swine together with the debris)

Photo 50. Shallow tubewell in Jalaur-Suage.

Photo 51. Vegetations that clogged the end check and drainage outlet of Jalaur Extension RIS.

Photo 52. Checkgates at Lateral F, Jalaur Extension RIS.
Take note of the floating debris on the left side.

Photo 53. Lined section of Lateral F, Jalaur Extension RIS.

Photo 54. A shallow tubewell (well point system) in the midstream section of Jalaur Proper RIS.

Photo 55. Downstream section of Lateral C, Jalaur Proper RIS.

Photo 56. Direct turnout along Main Canal, Jalaur Proper RIS.

Photo 57. Section of Lateral B, Jalaur Proper RIS.

Photo 58. Check gate structure of Lateral B, Jalaur Proper RIS.

Photo 59. A pumpset along Main Canal, Jalaur Proper RIS.
Take note of the width of the canal and vegetations along.

Photo 60. Section of the Main Canal of Jalaur Proper RIS with vegetations.

Photo 61. A direct turnout in the midstream of Main Canal of Jalaur Proper RIS.

Photo 62. Newly-cleaned main farm ditch in Jalaur Proper RIS.

Photo 63. A checkgate using wood planks near the downstream of Main Canal of Jalaur Proper RIS. Take note of the debris on the right side of the canal.

Photo 64. Downstream section of Lateral G, Jalaur Proper RIS.

Photo 65. A re-use dam in Suague RIS.
The intake gate is on the left side covered with debris.

Photo 66. Section of the Main Canal, Suague RIS (midstream) with drainage intake (right side).

Figure 34. Iloilo groundwater potential map.

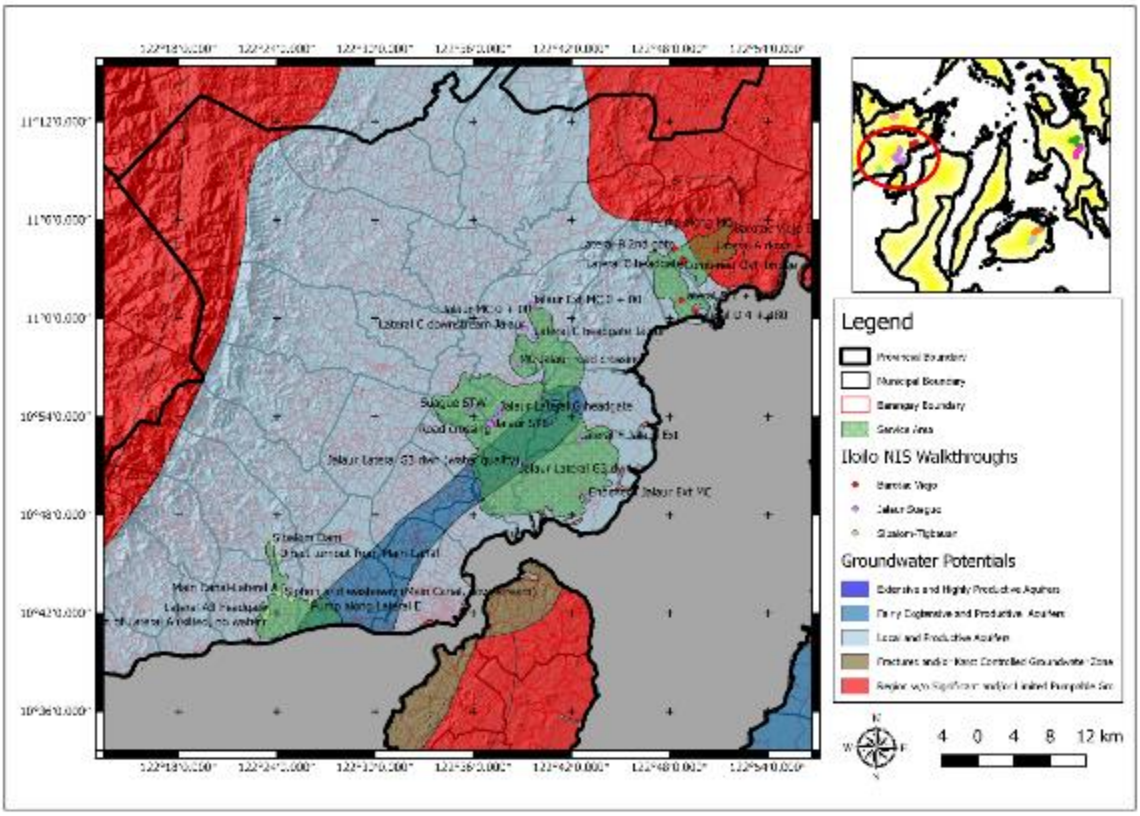


Figure 35. Iloilo Erosion Map.

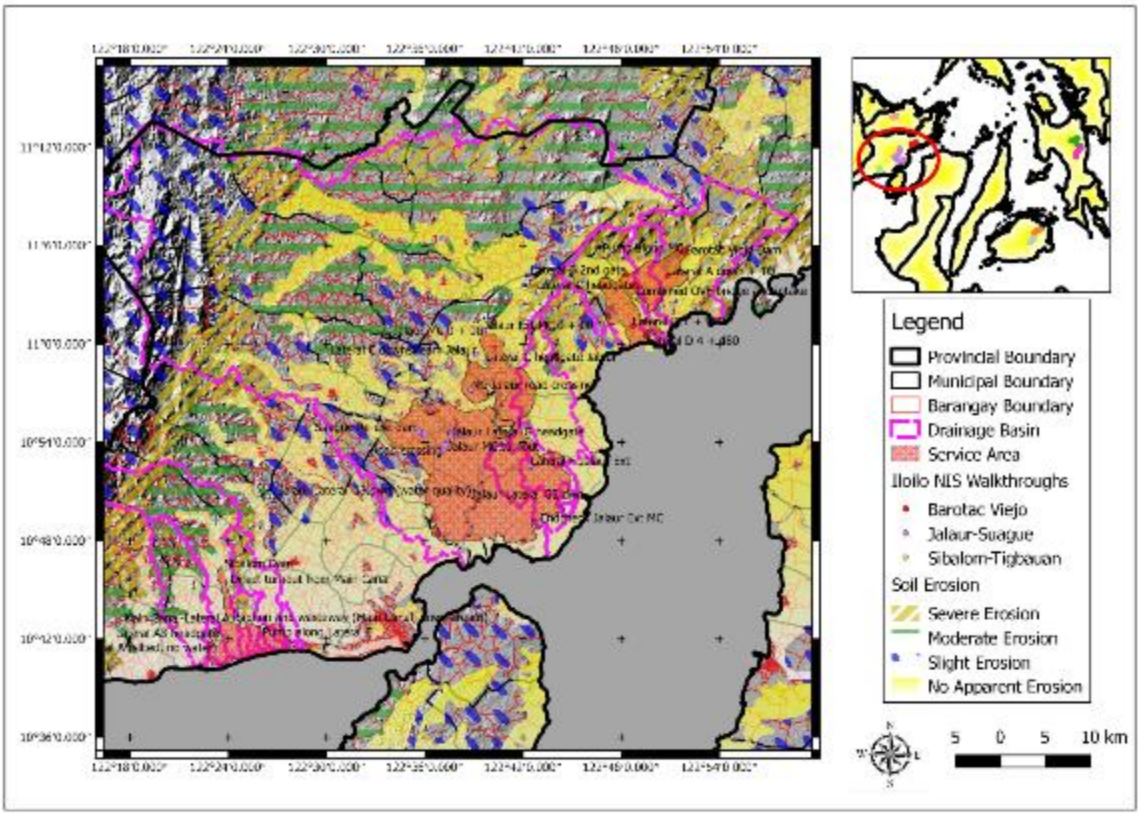
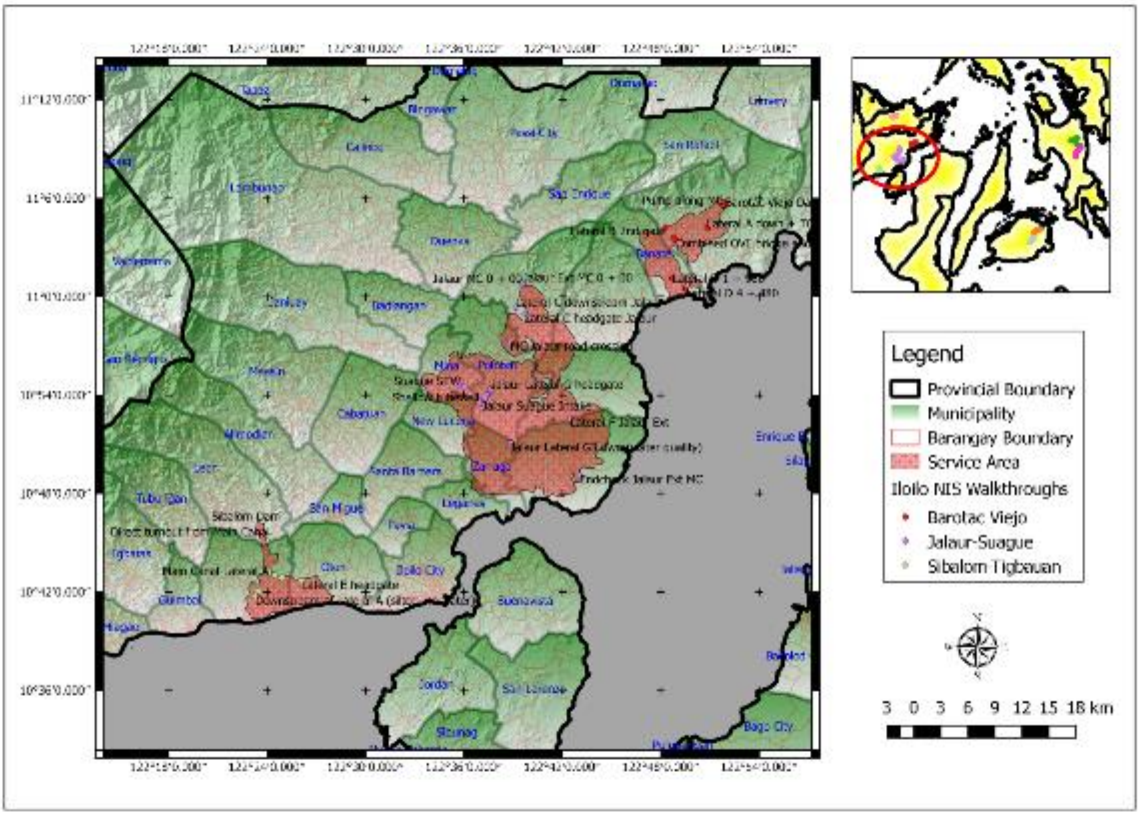


Figure 36. Iloilo walkthroughs and system boundaries.



5.1.5. Padada RIS

Padada RIS started operation in 1956 serving mostly the town of Hagonoy, Davao del Sur and some part of Digos City, Davao del Sur. The designed service area was 3,000 has while the firmed-up service area was 3,015 has. The main crops were rice and banana. The irrigated area and average yield per season for CY 2014-2017 is presented in Table 21 while for Dry season 2018 is presented in Table 22.

Table 21. Irrigated area and average yield per season of Padada RIS for CY 2014 to 2017

Season	Irrigated	Benefited	Average Yield Cav/Ha
WET	2669.07	2665.9	131 cav/ha
DRY	2623.76	2608.08	125 cav/ha

Table 22. Irrigated area and average yield per season of Padada RIS for CY 2018 Dry Season

As of June 30, 2018

NAME OF IA	SERVICE AREA			IRRIGATED AREA			FAILURE FOR RICE AREA	BENEFITED AREA			NUMBER OF FARMERS	C. I.	PROD'N
	RICE	BANANA	TOTAL	RICE	BANANA	TOTAL		RICE	BANANA	TOTAL			
	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)	(HAS)		%	Cav / Has
1. LAPOSA	355.50	4.50	360.00	330.45	-	330.45	-	330.45	-	330.45	391	91.79%	112
								-					
2. UPSFIA	416.90	8.10	425.00	414.09	8.10	422.19	-	414.09	8.10	422.19	425	99.34%	115
								-					
3. BIA	695.97	34.03	730.00	685.72	35.83	721.55	-	685.72	35.83	721.55	603	98.84%	114
								-					
4. BASISFIA	521.35	3.25	524.60	495.65	3.25	498.90		495.65	3.25	498.90	464	95.10%	115
								-					
5. SMIA	80.40		80.40	80.40		80.40		80.40	-	80.40	94	100.00%	110
								-					
6. SIA	300.00		300.00	179.76		179.76		179.76	-	179.76	268	59.92%	104
sub-total	**2,370.12**	**49.88**	**2,420.00**	**2,186.07**	**47.18**	**2,233.25**	**-**	**2,186.07**	**47.18**	**2,233.25**	**2245**		
BANANA (Multi)		595.00	595.00		461.53	461.53			461.53	461.53	4	77.57%	
TOTAL	**2,370.12**	**644.88**	**3,015.00**	**2,186.07**	**508.71**	**2,694.78**	**-**	**2,186.07**	**508.71**	**2,694.78**	**2249**	89.38%	**112**

The Padada RIS was part of the JICA project for Improving Operation & Maintenance (O&M) of National Irrigation Systems (3rd Technical Cooperation Project). The project's purpose is for the improvement of O&M schemes of NIS. The project duration was from May 2013 to April 2017. One of the activities of the project were the introduction of GIS which include the establishment of new parcellary map by Satellite imagery and the introduction of Farmland database/GIS in 10 pilot sites. The other pilot sites are presented in Table 23. Aside from Padada RIS, there were other NIS visited by the team which include Pampanga Delta, Caguray, Mambusao, Barotac Viejo, and Malinao RIS. Sample output of the JICA project for Padada RIS is shown in Figures 39 and 40. Moreover, it is commendable that the training and experience obtained by the staff in the JICA project were being used in other system under the IMO as well as in the CIS.

Table 23. Pilot sites for the improvement of O&M schemes in NIS

Name of NIS	Location	Service Area	Firmed-up Service Area	Number of Farmers
Amburayan RIS	Region I	3,489	3,289	9,074
Division 5	UPRIIS	18,050	17,850	17,456
Pampanga Delta	Region III	13,158.54	10,830.27	5,771
Caguray RIS	Region IV-B	3,308	1,990	742
Mambusao RIS	Region VI	1,423	1,372	828
Barotac Viejo RIS	Region VI	2,124	1,700	805
Malinao RIS	Region VII	4,950	4,740	11,503
Padada RIS	Region XI	3,512	3,015	2,275
Lasang RIS	Region XI	4,928.92	4,928.92	1,931
Lower Agusan River PIS	Region XIII	6,000	4,492.75	1,825

Figure 37. Geotagging of location of stuctures in Padada RIS from JICA Project.

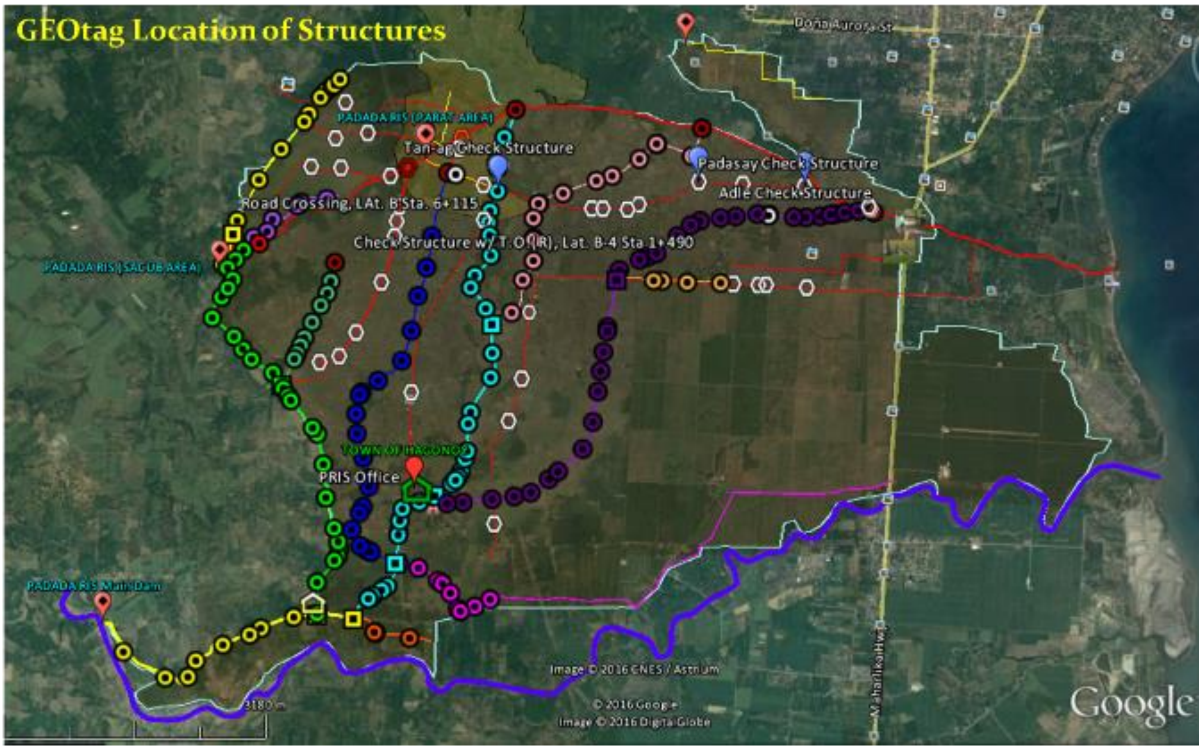
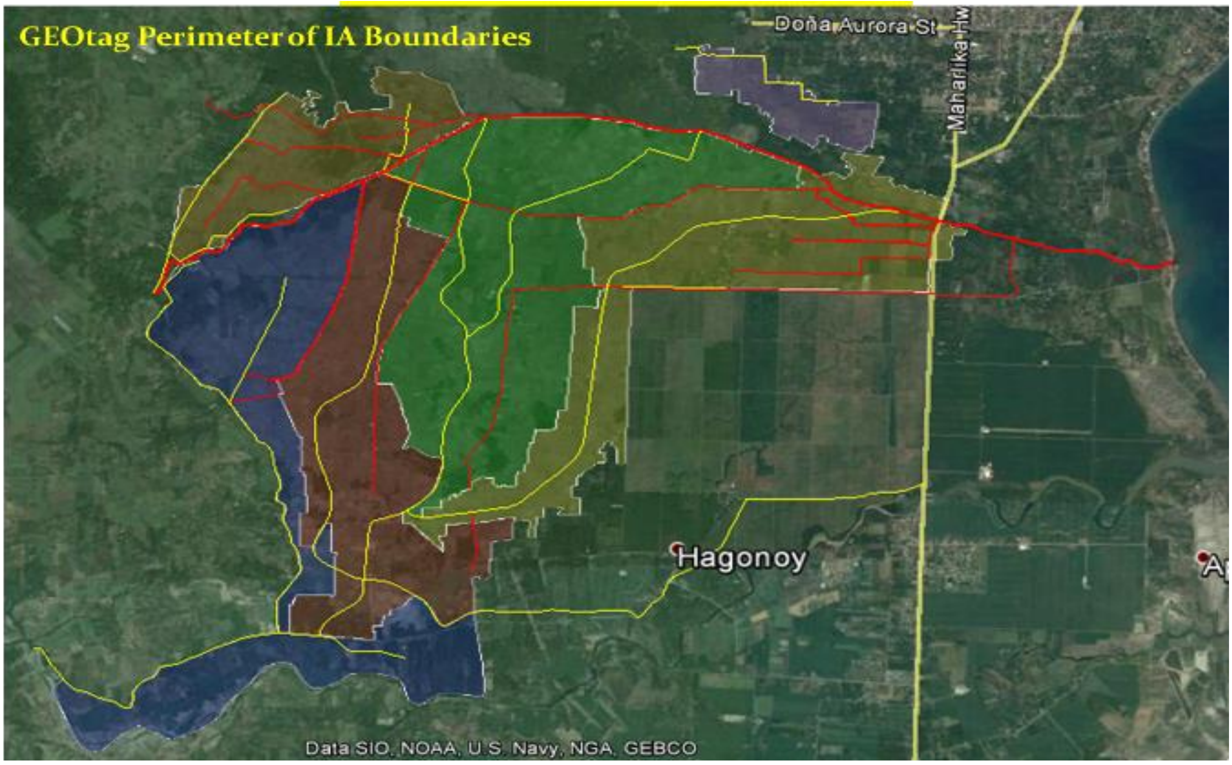


Figure 38. Geotagging of perimeter of IA Boundaries in Padada RIS from JICA Project.



During the time of visit at Padada RIS, the unlined sections of Main Canal were being lined (Photo 67). The Laterals and Main Canals of other supply dams (Photo 68) were turned over to IAs (part of Modified IMT) as presented in Table 24. Of the total length (42.565 kms) of canal sections managed by the IAs, about 69.5% were unlined (Table 23). System layout and parcellary map of Padada RIS is shown in Figures 39 and 40.

Photo 67. Newly lined headwater section of Padada RIS Main Canal.

Photo 68. Parat dam along Sacub river (Intake dam for Padada RIS area).

Table 24. Area and canal sections covered per IA of Padada RIS

NAME OF IA	FUSA	CANALS						CONTRACT
		NAME	STATION		LENGTH	TYPE		
	(has)		FROM	TO	(km)	LINED	UNLINED	
LAPOSA	360.00	Lat. A	0+000	5+520	5.520	4.620	0.900	IMT
		Lat. A-1	0+000	1+640	1.640	1.640	0.000	
		Lat. AA	0+000	0+747	0.747		0.747	
		Sub-Total			**7.907**	**6.260**	**1.647**	
UPSFIA	425.00	Lat. B	0+000	1+983	1.983	1.783	0.200	IMT
		Lat. B-1	0+000	1+457	1.457	0.451	1.006	
		Lat. B-2	0+000	5+450	5.450	1.240	4.210	
		Sub-Total			**8.890**	**3.474**	**5.416**	
BIA	730.00	Lat. B	1+983	7+720	5.737	0.977	4.760	IMT
		Lat. B-4	0+000	4+180	4.180		4.180	
		Sub-Total			**9.917**	**0.977**	**8.940**	
BASISFIA	524.60	Lat. B-3	0+000	7+200	7.200	0.255	6.945	IMT
		Lat. B-3A	0+000	1+060	1.060		1.060	
		Sub-Total			**8.260**	**0.255**	**8.005**	
SMIA	80.40	MC	0+000	2+305	2.305	1.010	1.295	TYPE III
		Sub-Total			**2.305**	**1.010**	**1.295**	
SIA	300.00	SK MC	0+000	2+840	2.840	0.030	2.810	IMT
		SK Lat. A	0+000	1+415	1.415	0.300	1.115	
		Parat LMC	0+000	1+031	1.031	0.691	0.340	
		Sub-Total			**5.286**	**1.021**	**4.265**	

Figure 39. Area boundaries of the different IAs of Padada RIS with canal layout and parcellary map.

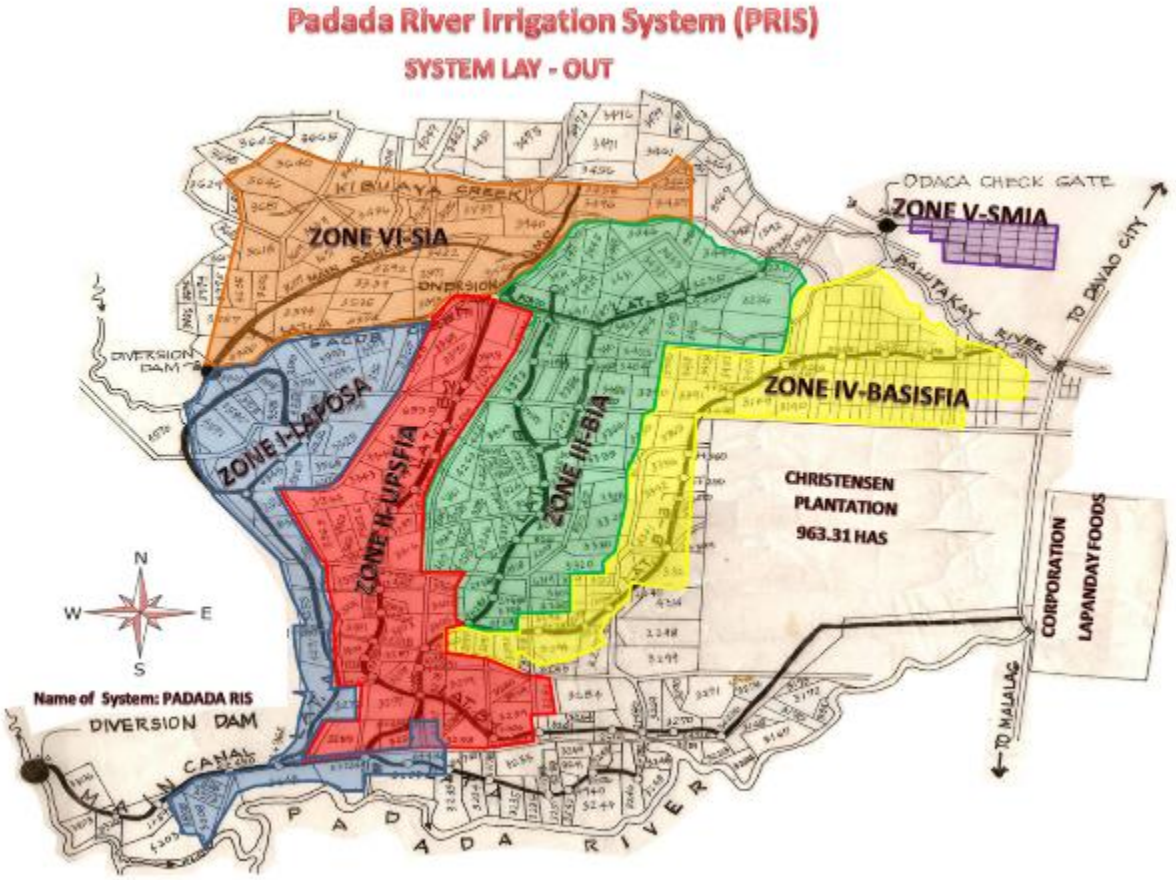


Figure 40. Canal layout and parcellary map of Padada RIS with other intake dams.

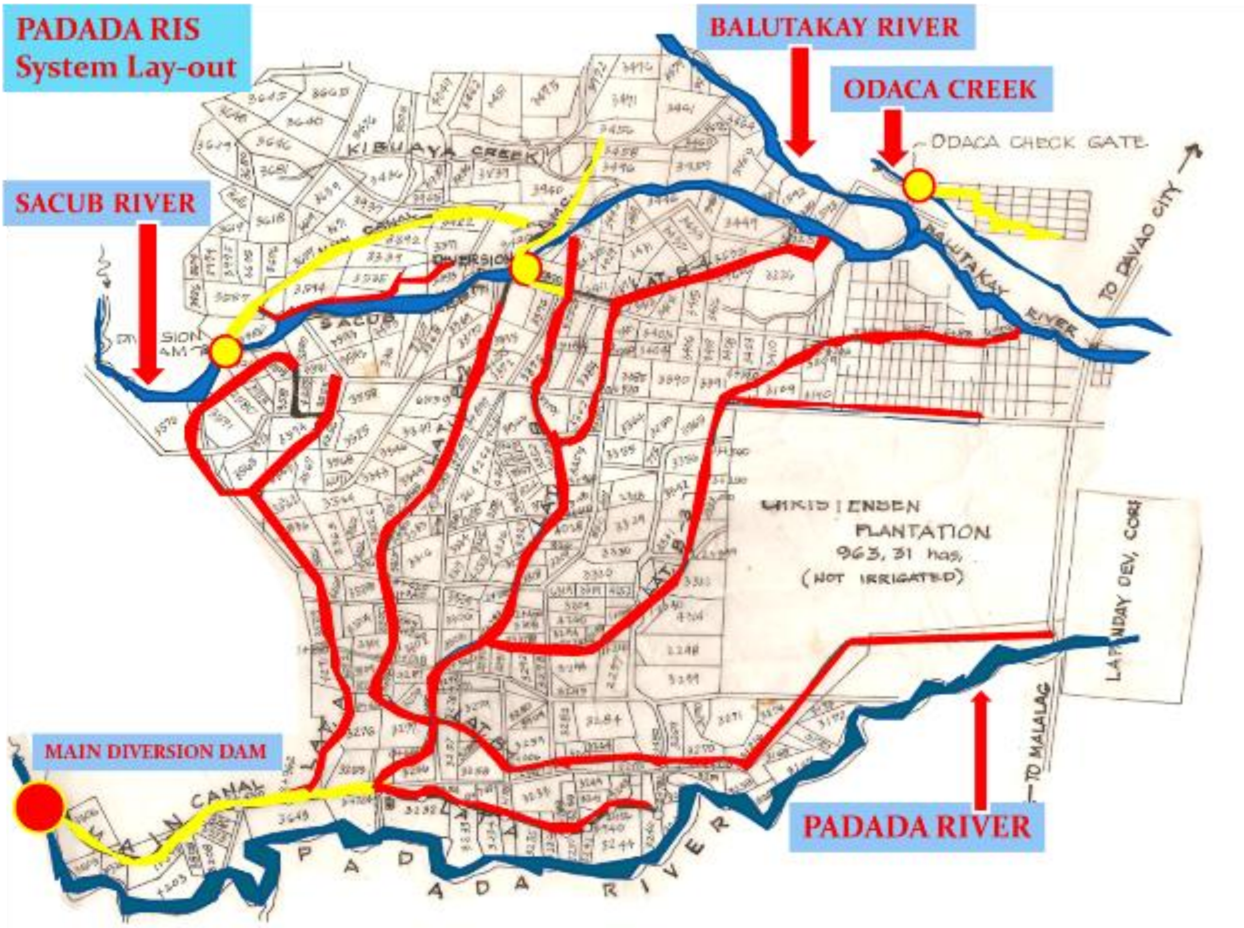


Photo 69. Bridge crossing over the Main canal of Padada RIS.

Photo 70. Problem at the dam site due to over quarrying near the downstream section of Padada RIS dam.

Photo 71. Take note of the standby STW as water source during dry spells.

At the time of survey, sections of Main Canal were being lined. Silts being removed from the canal as evidence of heavy siltation plus freshwater shellfish could be observed. Due to the on-going canal linings in Padada RIS, calibration of staff gages has to be done after completion.

A water delivery schedule for Padada RIS is presented in Figure 41. Still, the system encountered illegal turnout and pumping at night. Sometimes, the system operators seek assistance of the police and barangay officials in enforcing the schedule. Moreover, there also issues with illegal settlers along drainage and other section of the Padada RIS which include garbage dumping and canal damages among others.

Figure 41. Sample water delivery schedule.

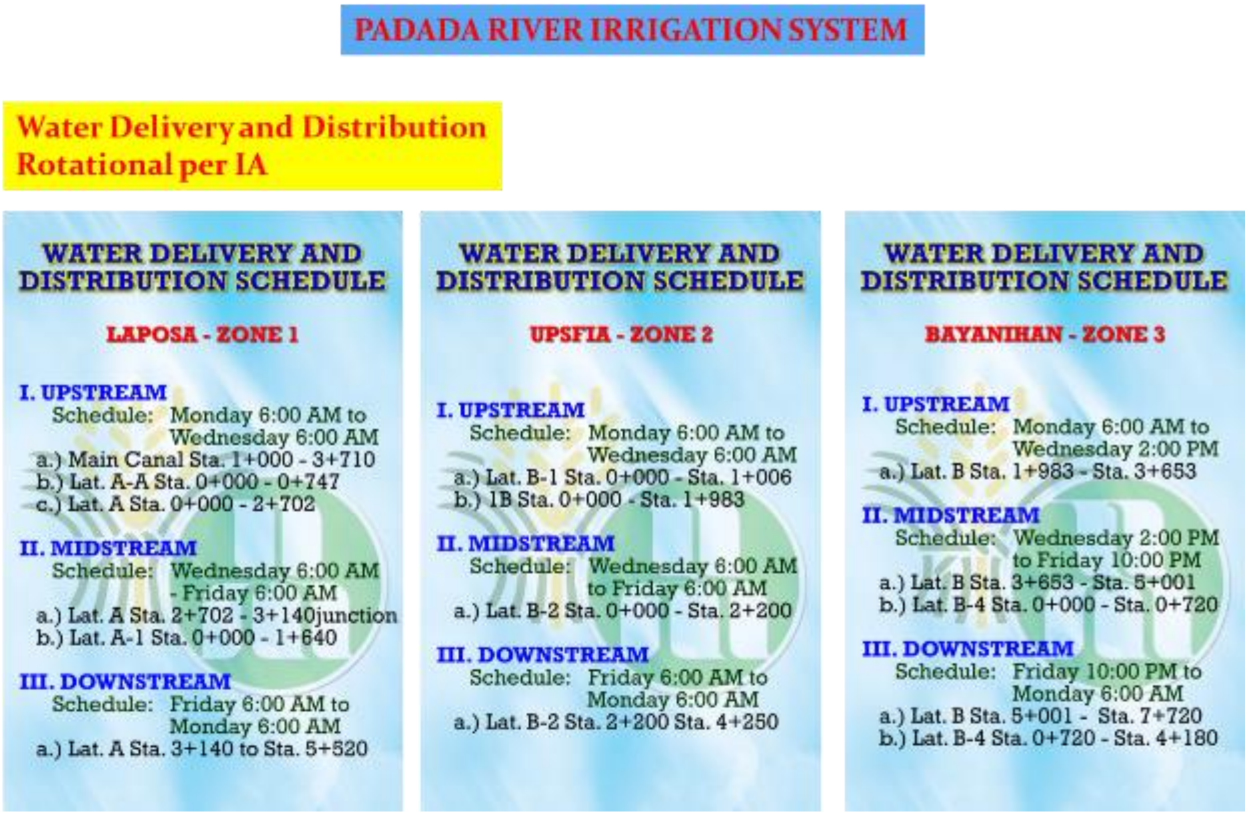


Photo 72. Illegal settlers along the drainage.

During the field visit in Padada RIS, we observed some odd structures. The headwater of Lateral A has two checkgates (Photos 73 and 74). Additional gate was installed to increase water intake into the Lateral. On the other hand, the silt ejector opposite the headgate of Lateral B was converted into farm turn out (Photo 75).

Photo 73. First intake gate of Lateral A.

Photo 74. Second intake gate of Lateral A.

Photo 75. Silt ejector converted into supply gate opposite Lateral B headgate.

Photo 76. Portion of lined section followed by unlined section in the downstream of Padada RIS.

Photo 77. Pump house beside a reuse point in Padada RIS.

Photo 78. Padada RIS dam.

Photo 79. Silted main canal of Padada RIS.

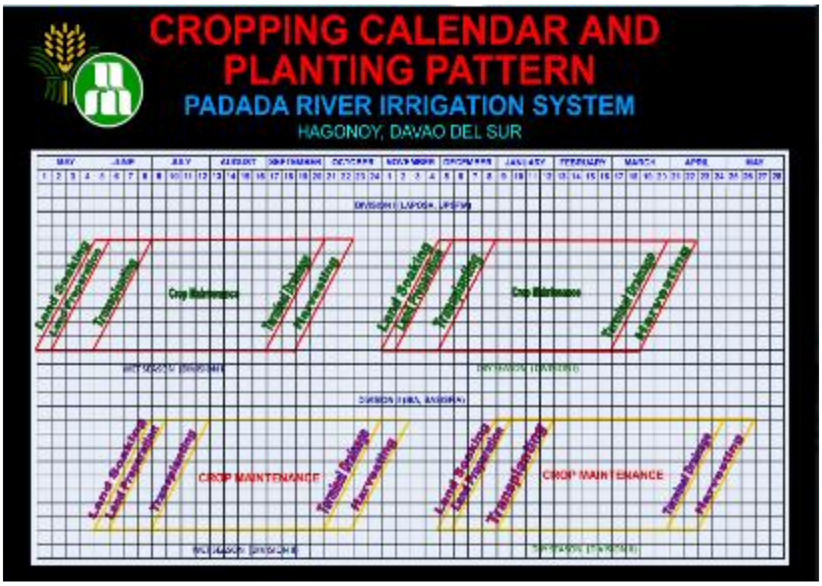
Photo 80. Main canal above designed water level in Padada RIS.

Photo 81. Portion of the Farm to Market Road that was a marshland before.

Figure 42. Padada RIS general information.

(Source: Padada RIS IMO)

Figure 43. Padada RIS Cropping Pattern.



(Source: Padada RIS IMO)

Figure 44. Davao del Sur groundwater potential map.

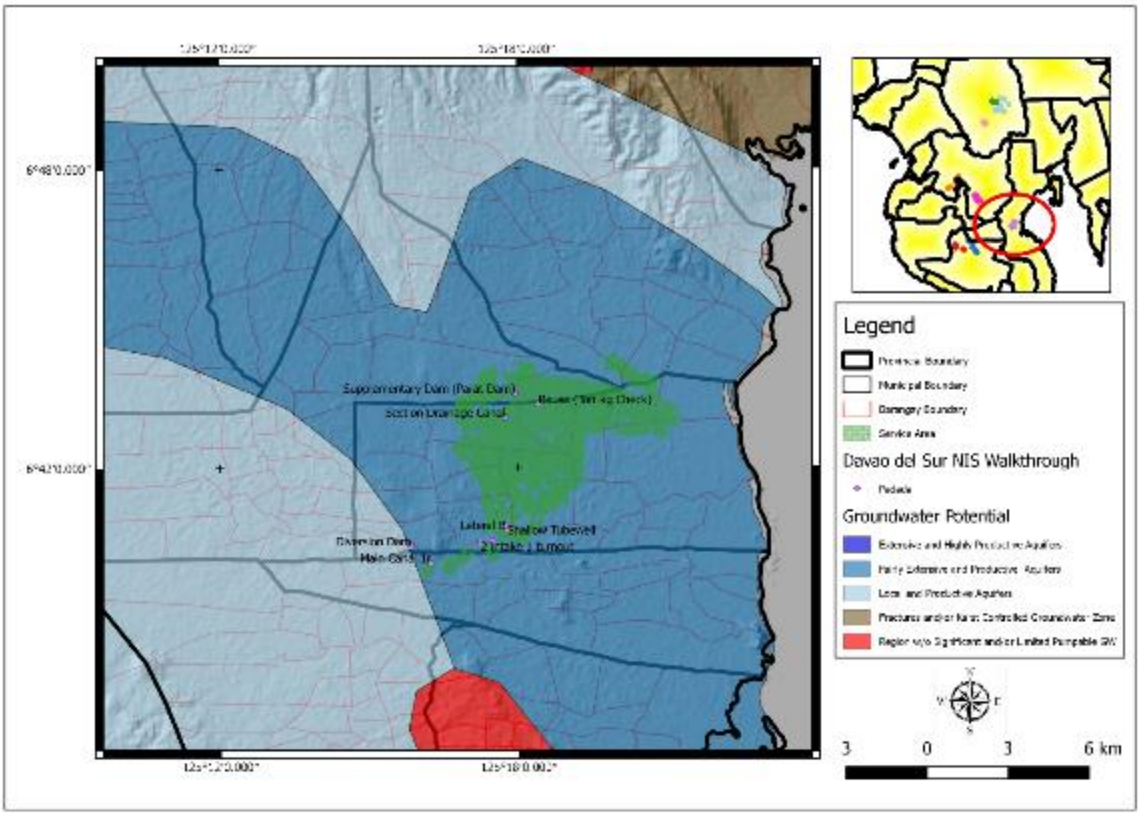


Figure 45. Davao del Sur Erosion Map.

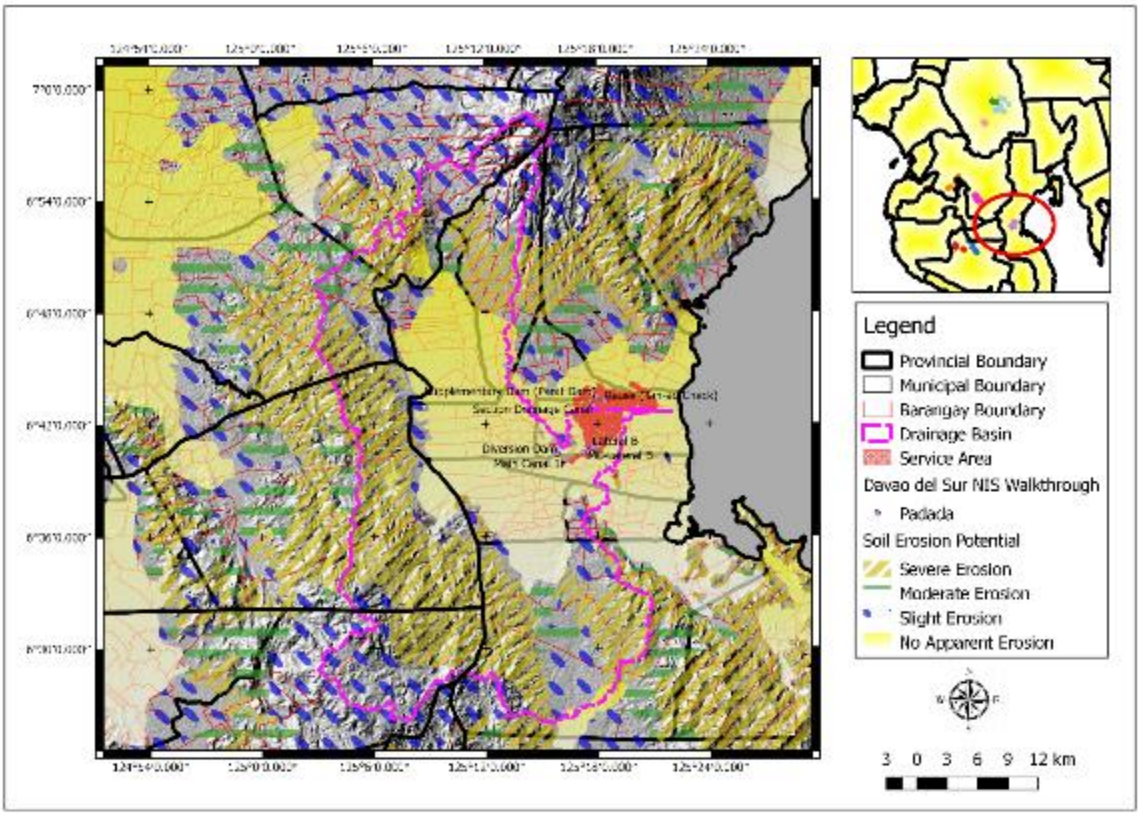
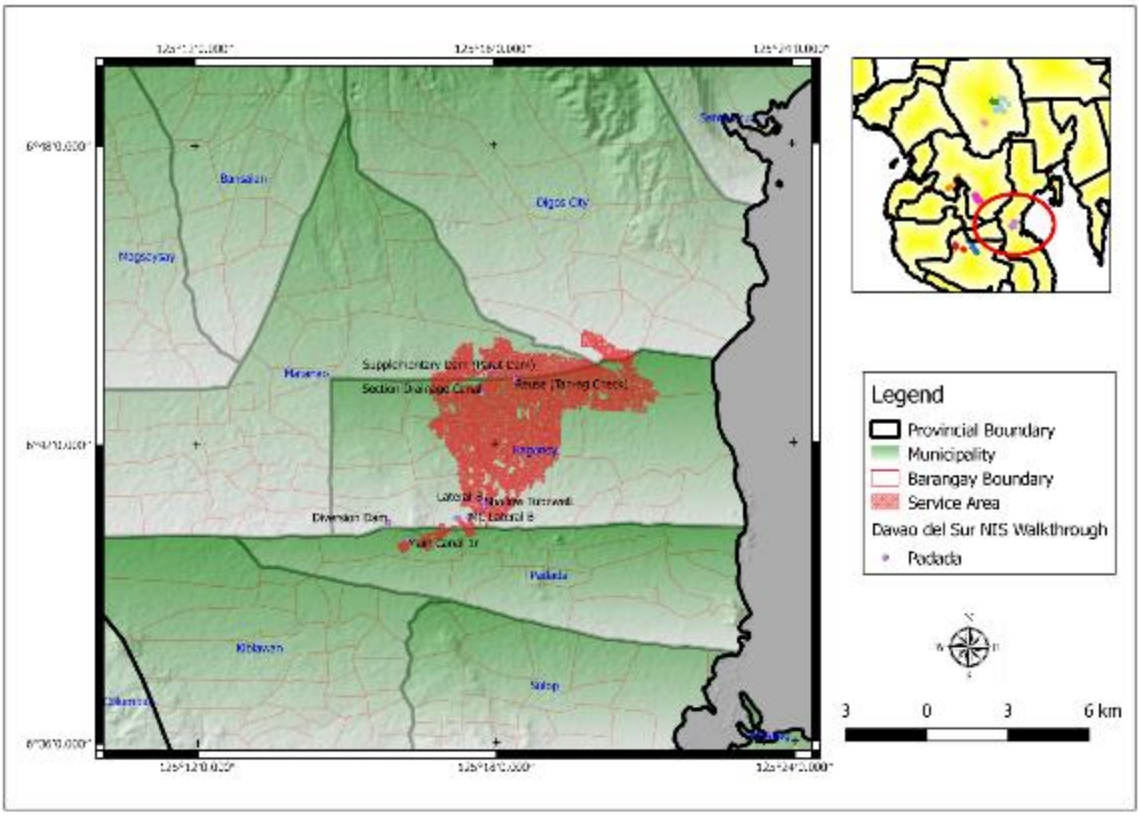


Figure 46. Davao del Sur walkthroughs and system boundaries.



5.1.6. Marbel #1 RIS

The Marbel#1 RIS diversion dam (Photo 82) is located in Koronadal, South Cotabato (Lat - 6°24’30”; Long - 124°54’17”) serving the Koronadal City and Municipality of Tantangan. The system started operation in September 1973 with a potential area of 2,700 has. As of August 2018, FUSA is about 2,042.78 has with 18 IAs serving 1,458 members (Figure 47).

Photo 82. Diversion dam of Marbel #1 RIS.

Figure 47. Layout map of Marbel #1 RIS with relative locations of the 18 IAs area boundaries

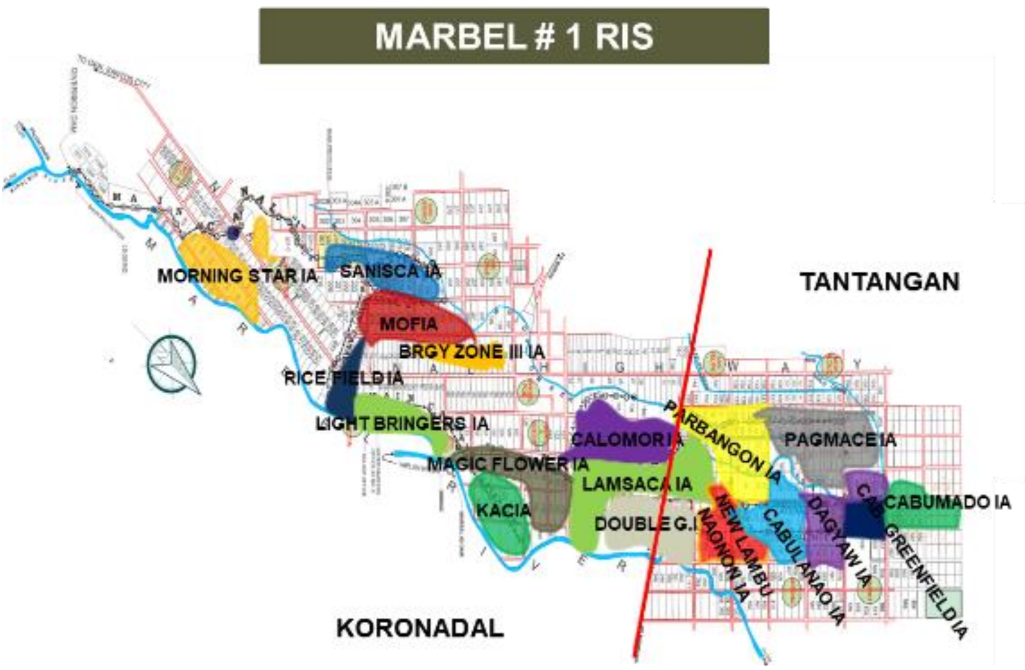
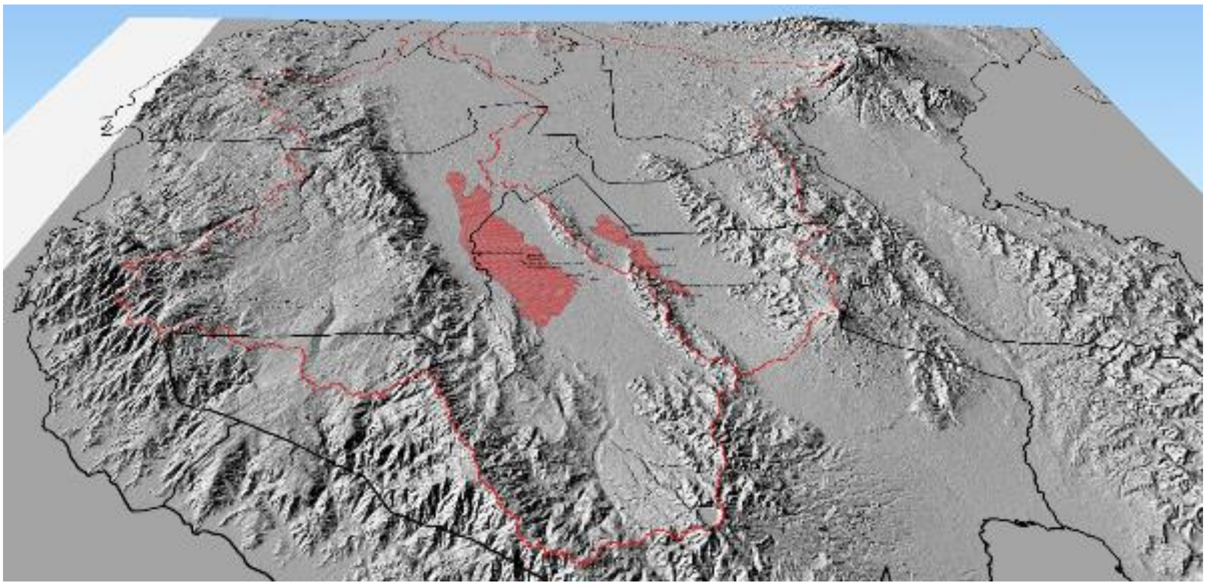


Figure 48. 3D map showing the area around Marbel #1 and Banga RIS



The designed river discharge for Marbel #1 RIS was 5.44 CMS but the river discharge was only about 2.726 CMS (Table 25). The total watershed area is about 203.0 km². Due to low river discharge, supplementary water was being drawn out from Calalima and Bulok Creek as re-use dams. There were about 18 re-use dams that irrigate about 358 has. An example is the Bulok Dam presented in Photo 83.

Table 25. Mean monthly river discharge of Marbel #1 RIS from 2005-2017

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2005	3,204.00	3,130.00	2,865.00	1,680.00	3,185.00	3,264.00	3,156.00	1,938.00	1,415.00	2,820.00	3,317.00	3,628.00
2006	2,771.00	2,840.00	2,522.00	3,060.00	2,988.00	3,134.00	1,733.00	1,980.00	2,000.00	1,916.00	2,851.00	2,736.00
2007	2,667.00	2,817.00	2,937.00	3,010.00	3,093.00	3,364.00	3,594.00	3,242.00	3,240.00	2,760.00	3,060.00	3,313.00
2008	3,305.00	3,046.00	2,954.00	2,518.00	3,623.00	3,000.00	2,387.00	1,998.00	2,976.00	3,260.00	2,919.00	2,663.00
2009	1,975.00	3,044.00	2,717.00	3,501.00	3,623.00	2,786.00	2,554.00	2,840.00	2,652.00	3,004.00	2,839.00	2,487.00
2010	1,793.00	1,657.00	1,487.00	1,855.00	2,644.00	2,966.00	2,943.00	3,354.00	2,405.00	1,890.00	2,501.00	3,167.00
2011	2,676.00	2,243.00	2,487.00	2,561.00	3,162.00	2,102.00	1,903.00	2,904.00	3,019.00	2,687.00	3,051.00	2,690.00

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2012	2,420.00	2,781.00	2,730.00	2,592.00	1,173.00	2,304.00	1,136.00	2,202.00	1,929.00	2,568.00	2,388.00	2,709.00
2013	1,811.00	2,933.00	2,373.00	2,402.00	2,687.00	2,554.00	2,657.00	1,762.00	2,333.00	2,422.00	2,583.00	2,422.00
2014	2,594.00	2,480.00	2,457.00	2,396.00	2,592.00	2,390.00	2,549.00	2,476.00	2,429.00	2,569.00	2,092.00	2,339.00
2015	2,575.00	2,579.00	3,125.00	2,972.00	2,682.00	2,321.00	2,562.00	2,384.00	2,288.00	2,568.00	2,510.00	2,753.00
2016	3,010.33	2,074.14	450.00	915.00	3,026.00	2,953.00	2,805.00	2,607.00	1,463.00	2,253.00	2,559.00	2,489.00
2017	1,916.13	1,579.00	2,257.00	2,359.00	2,378.00	2,674.00	2,484.00	2,343.00	2,268.53	2,423.74	2,650.00	1,901.55
Mean	2,516.73	2,554.09	2,412.38	2,447.77	2,835.08	2,754.77	2,497.15	2,463.85	2,339.81	2,549.29	2,716.92	2,715.20

Photo 83. The Bulok Dam (re-use) of the Marbel #1 RIS.

Even though the water supply from the Marbel #1 RIS was relatively low, the cropping intensity was relatively high with an average of 100% for wet season from 2013-2017 (Table 26). One of the reasons is the installation of multiple re-use and supplementary dams. The high cropping intensity could also be attributed to the 100% lined canals. There were about 21.57 kms of Main Canal and about 23.51 kms of Lateral Canals supported with 45.46 kms of service roads (Photos 84 and 85). Canal layout map of Marbel #1 RIS is presented in Figure 49.

Table 26. Cropping Intensity of Marbel #1 RIS for Dry and Wet Season from 2013-2017

YEAR	DRY	WET	AVERAGE
2013	97.80	99.39	98.595
2014	100.04	100.00	100.02
2015	95.34	102.19	98.765
2016	100.04	99.30	99.67
2017	98.85	98.79	98.82
AVERAGE	98.414	100.042	

Photo 84. Section of Main Canal of Marbel #1 RIS at the headgate of Lateral E.

Photo 85. Section of Main Canal of Marbel #1 RIS at the headgate of Lateral H1.

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The 100% lined canal status of the Marbel #1 RIS were achieved through continuous repair and rehabilitation of the system as shown in the list of POW from 2013-2017 in Table 27. Another reason for the high cropping intensity is the synchronized planting. In this system, the midstream (Division B, Figure 52) first, then upstream and downstream section were simultaneous (Divisions A and C, Figure 50). The reason was for the downstream section to receive excess of midstream section. The synchronized planting is also coordinated with Marbel #2 RIS. The Marbel #2 RIS (Photo 86) is irrigating the right side of the river while Marbel #1 serves the left side. With the coordinated scheme, the midstream of Marbel #1 should not be simultaneous with midstream of Marbel#2. It could also be observed that another reason for high cropping intensity of Marbel #1 RIS is the reduction of silt in the canals. The system is operating the silt ejector (Photo 87) and wasteways (Photo 88) once a month.

Figure 49. Canal layout map of Marbel #1 RIS

Table 27. List of POW for Marbel #1 RIS from 2013 to 2017

YEAR	TYPE	AMOUNT (₱)
2013	Concrete Pavement	1,649,000.00
	NIS Extension	31,501,000.00
2014	NIS Extension	27,667,000.00
2015	Rehab and Reconstruction	5,000,000.00
	Restoration/ Rehab/ Repair	4,000,000.00
2016	Repair and Rehab	12,000,000.00
2017	Restoration/ Rehab/ Repair	10,000,000.00
	(Congressional Fund)	10,000,000.00
	Coco-net Slope	2,025,000.00

Figure 50. Layout of the Marbel #1 RIS showing the different Divisions.

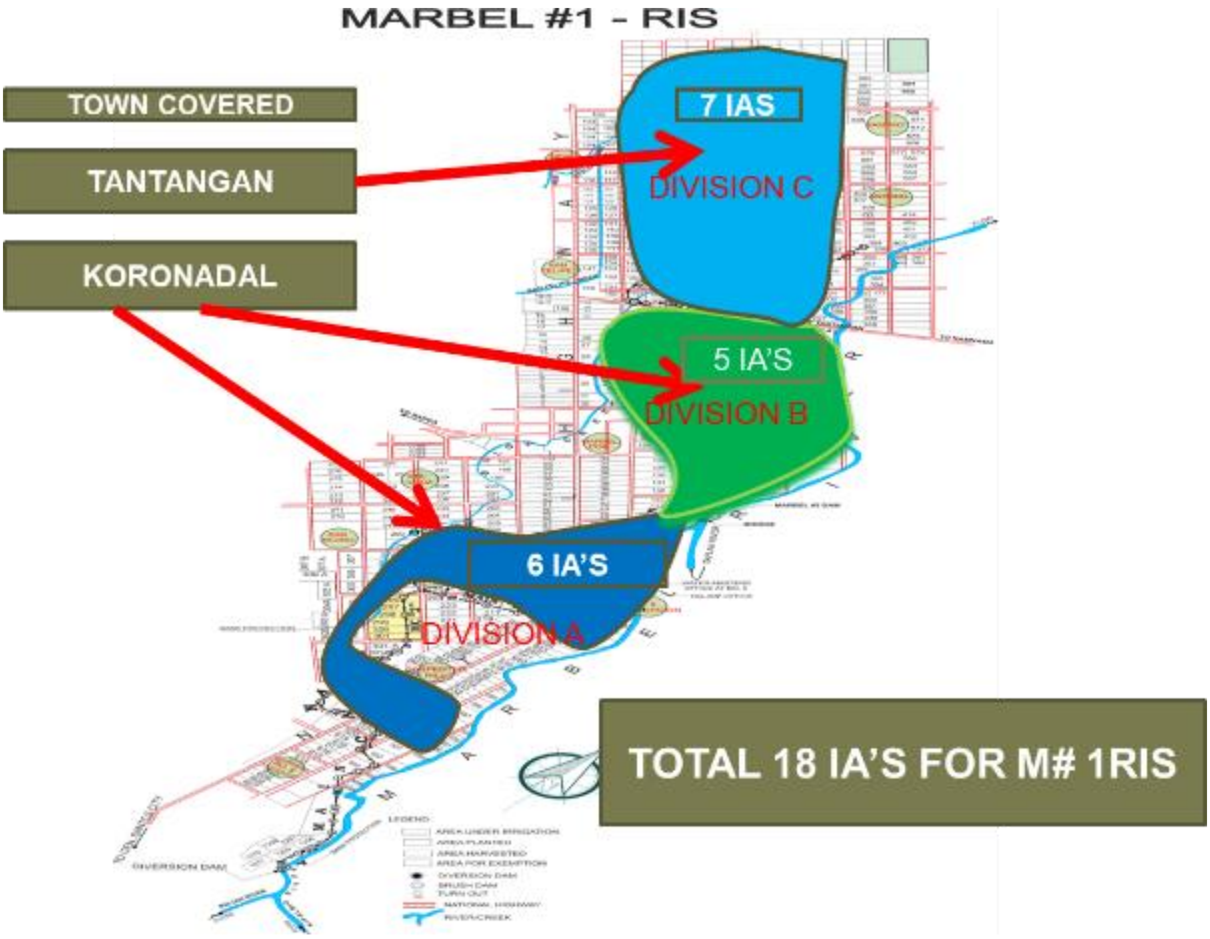


Photo 86. Diversion dam of the Marbel #2 RIS.

Photo 87. Control gates of the silt ejector of Marbel #1 RIS.

Photo 88. Control gate of one of the wasteways of Marbel #1 RIS.

Figure 51. General information of Marbel #1 RIS.

NAME OF SYSTEM	MARBEL 1 RIS
Province	South Cotabato
Municipality	Koronadal and Tantangan
Year constructed	1971
Date of operation	September 1973
Potential area (has)	2,700.00
Firmed-up service area	2,042.78
No. Ia's	18
IA Members	1,458
Project Cost	11,000,000.00
Source of Water	
Main	Palian & Kipalbig River
Supplementary	Calalima and Bulok Creek
Type of Dam	Ogee
Diversion Length (m)	50
Diversion Height (m)	3.80
River Discharge (cms)	2.726
Designed River Discharge (cms)	5.44

Photo 89. Silted section of Marbel #1 RIS.

Figure 52. South Cotabato groundwater potential map.

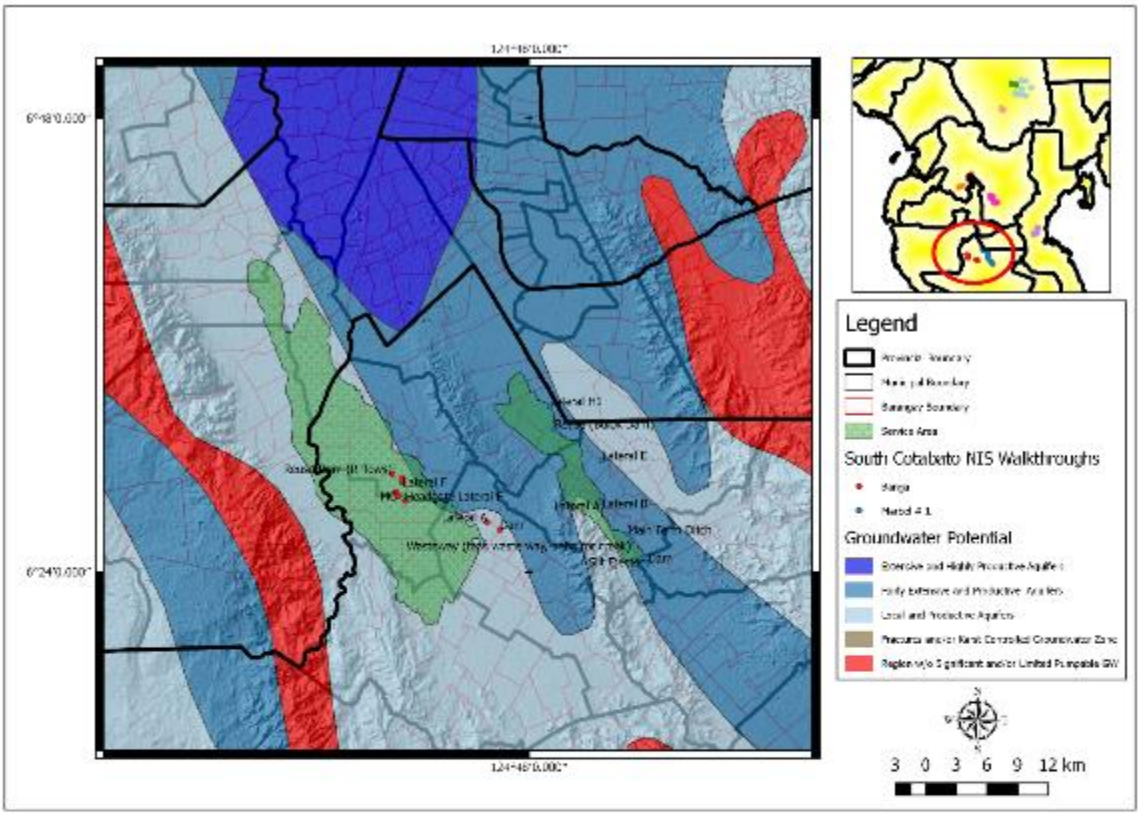


Figure 53. South Cotabato Erosion Map.

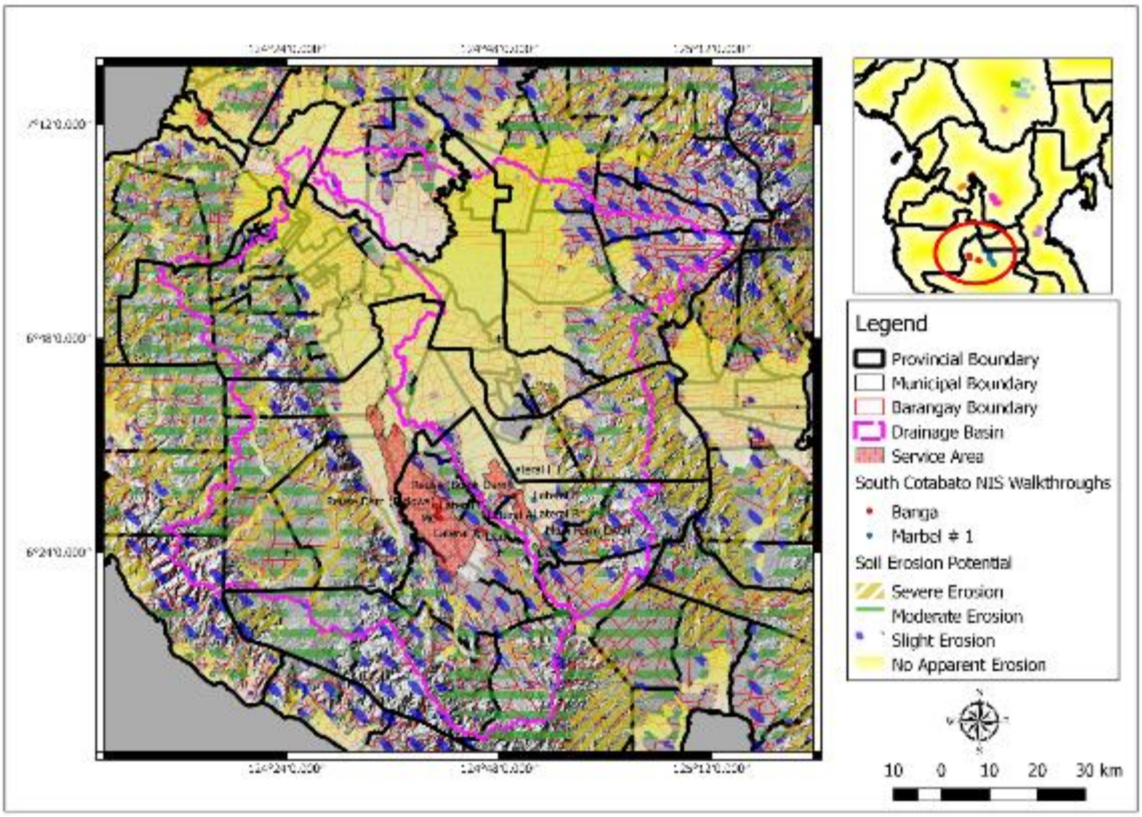


Figure 54. South Cotabato walkthroughs and system boundaries.

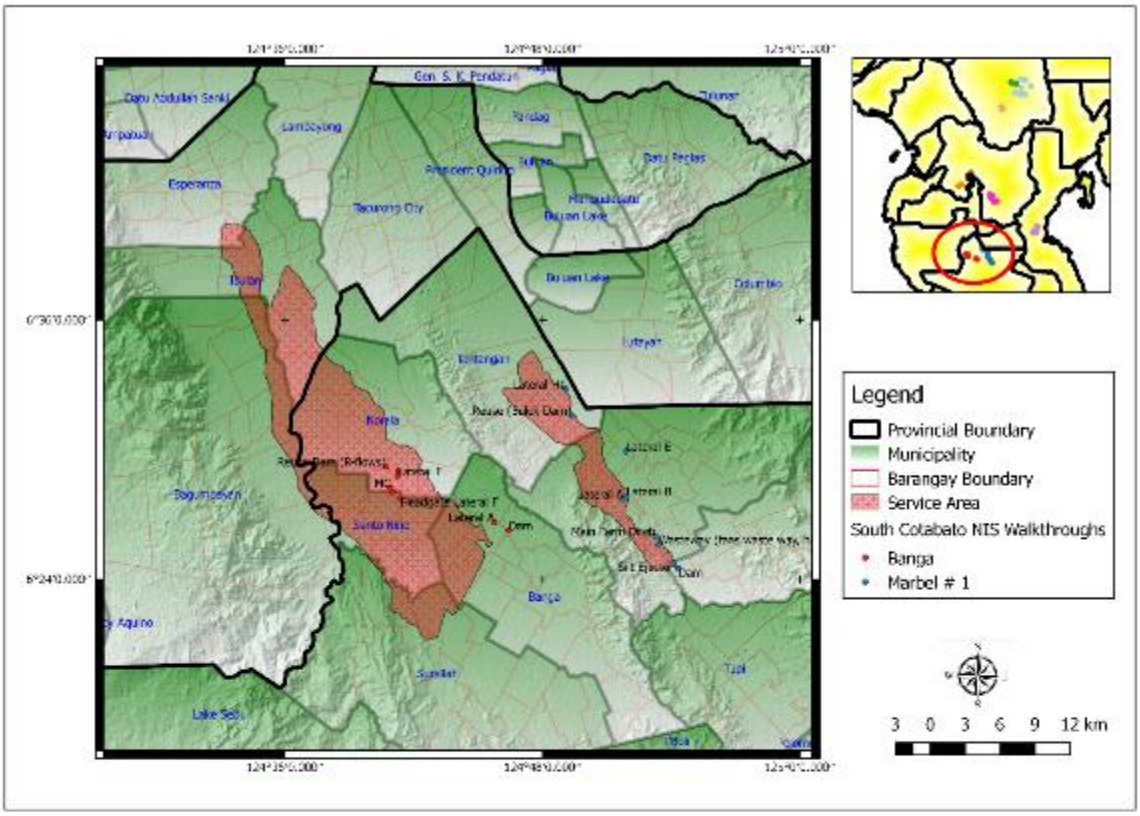


Table 28 summarizes the issues/concerns observed in selected NIS in Bohol, Iloilo, Davao del Sur and South Cotabato. As in Luzon, the main technical problem is siltation of canals especially the unlined canals which further contributes to the poor water distribution especially in the downstream part of the main canal. The Institutional issue revolves on weak enforcement of policies with regards to illegal settlers/pumping/garbage dumping and stealing of structures, high costs of inputs, difficulty in collecting Association and O&M dues and water distribution, etc. The environmental concerns are due to poor water quality as reflected in low DO and high pH and EC, which could have affected the yield in those NIS (please see section on water quality).

Table 28. Summary of Technical, Institutional and Environmental issues confronting the representative NIS in Visayas and Mindanao (Jalaur-Suague RIS, Iloilo; Malinao, Capayas Bayongan IS, Bohol; Padada RIS, Davao del sur; and Marbel #1, South Cotabato)

	Technical Issues	Institutional Issues	Environmental Issues
Bohol	Slow rehabilitation of damaged canals and FMR	Illegal pumping and garbage dumping	7 sites in Capayas and Bayongan, Bohol NIS have shown low pH (<5) and low DO (ard 4.5ppm) indicating that it is bit acidic and is lacking in dissolved oxygen. But EC is hard 200 uS/cm which is OK in terms of salinity level
	Lateral C is partially filled with stones	Less than 100% collection efficiency of Annual Dues	
	Abandoned area (reuse point)	High cost of farm inputs, low cost of rice product	
		Lack of manpower in canal cleaning	
	No water during dry season	Stealing of water and illegal check structures	
	Lack of postharvest facilities		
	Need for dam heightening		
Iloilo	Need to improve irrigation facilities	High cost of farm inputs, low cost of product	Most NIS cases in Iloilo showed pH levels on the alkaline side where 14 of 22 samples showed pH > 7. This was especially evident

	Technical Issues	Institutional Issues	Environmental Issues
			in all Jalaur measurements (9 locations) where pH was greater than 7 and EC was greater than 300 uS/cm in 3 out of 10 locations.
	Slow rehabilitation of damaged canals and demolished structures	Stealing of steel gates	Salinity as reflected by high EC (i.e. >300uS/cm) was also a problem in all Sibalom Tigbauan sites where all 5 measured values from laterals, main canals, turnouts showed values greater than 400uS/cm and 2 out of 4 locations showed high pH (>7).
	Needs drainage structures	Drainage outlet draining into the canal	
	Silted canals	Shortage of water	
		Delayed water delivery	
		Illegal turnouts	
Davao del Sur	Many portions of the canal system are unlined	High cost of farm input, low cost of palay	DO is <6ppm, EC > 300 uS/cm and pH >7 in 4 out 5 NIS sites in Padada Davao del Sur, which are indicative of the low quality of water in the area.
	Damaged steel gates	High cost of fertilizer	
		Members are not paying the Association Sustainable Dues	
South Cotabato	Silted canals	Delayed response on reports of water stealing and damaging of structures	12 out of 12 NIS sites in Marbel and Banga South Cotabato have pH >7, 8 out of 12 have DO <6 ppm which indicates low water quality in most sites in South Cotabato. However only 2 out 12 sites have EC > 300 uS/cm which are located in downstream part of Marbel sites

	Technical Issues	Institutional Issues	Environmental Issues
	Need back hoe for cleaning	Contaminated water	
	Unfinished lining of the canals	Water shortage	
	Unfinished construction of supplementary dams	Presence of debris	
		Difficulty in collecting O&M dues	
		High cost of inputs, low price of products	
		Lack of government support	

5.1.7. GIS Mapping

GIS techniques is a potentially valuable tool for NIS design and management. Using GIS map overlay, the study of NIS cases in Luzon is able to show the unsuitability of significant proportions of NIS service areas to irrigated rice farming. One representative case is that of MARIIS, a large system with about 80,000 ha service area, and the Erosion Map showed reduction in FUSA by 16% in terms of the erodibility of the soil alone. On the other hand, the overlaid GIS map indicate only 54% of the total FUSA in MARIIS is most suitable to irrigated rice agriculture (see succeeding Section). Conversely, 46% is unsuitable – which may be the reason why sub-optimal yields are obtained within the system. Similarly, diagnostics are performed for the other systems, with varying estimates of irrigated rice suitability. Likewise, GIS maps document as well as the degraded state of some NIS watersheds, accounting in part for the heavy siltation in these systems. Groundwater maps show areas with high potential for groundwater resources to supplement inadequate water supplies from surface water.

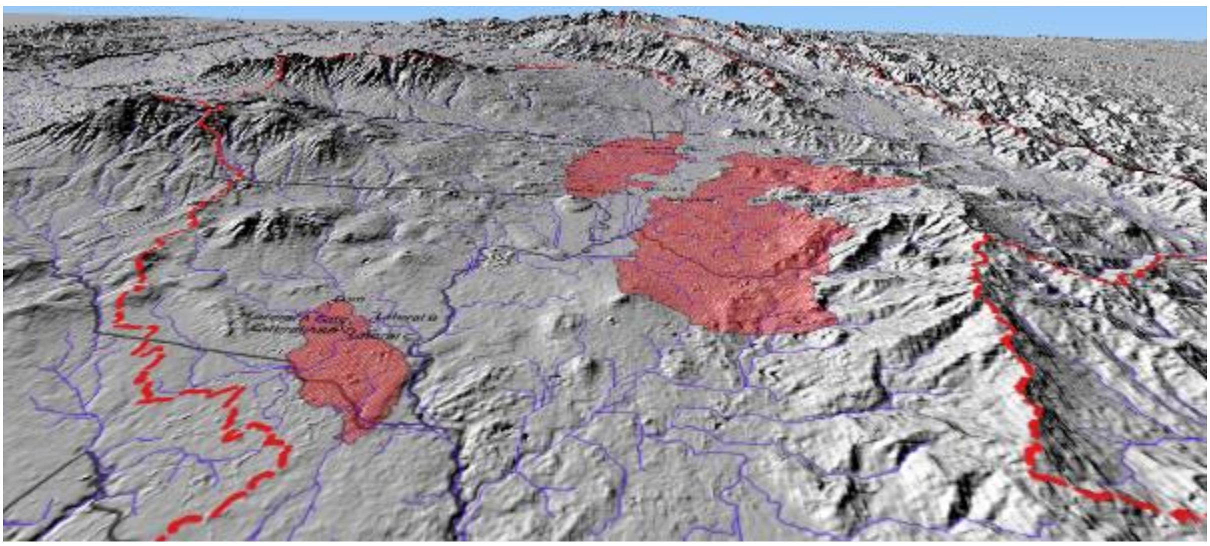
The performance levels (using PCA) of the 151 IAs considered in the analysis is presented in GIS maps. This is aimed to demonstrate the spatial distribution of irrigation performance among the different NIS cases and show which IAs are performing well or not. This is presented in the succeeding section under the Principal Component Analysis.

GIS maps are to show the location of field walkthroughs and measurements, erosion and ground water potential of all the provinces of the NIS cases covered (see Annex C). Most of the uplands from the downstream service areas have shown moderate to severe erosion. Although the erosion rates are not quantified in this study, sever erosion however is described by soil loss rate of 100 tons/ha per year or greater. The significance of mapping erosion potential in the NIS sites covered lies on the fact that runoff and flooding of lowland/irrigated areas depends on the typology and characteristics of the watershed which surrounds the irrigation service areas. The upland watershed can be prone to erosion depending on the combined effects of vegetative cover (land use), soil characteristics (erodibility), slope (topography) and rainfall patterns (erosivity). These factors are used as inputs in the Universal Soil Loss Equation (USLE) to estimate soil loss and erosion potential of a watershed. Many studies have shown which are validated by actual observations that eroded particles from upland areas are carried downstream areas which commonly cause siltation of water courses, irrigation canals and surface water systems. By mapping erosion potential, then we can assess which part of the watershed is prone to erosion, so we can propose land use planning and watershed management measures to minimize erosion potential and thus protect the lowland areas from sedimentation and siltation which are believed to be the causal factors for reduced flow capacity of canals and poor water distribution. Some representative maps are shown in the Technical section and all soil erosion maps are presented in the Annex C.

Estimation of ground water recharge on the other hand, seems to be out of scope in the present study since we need more time and data related to groundwater balance components such as rainfall, runoff, evapotranspiration, subsurface inflow and outflow and deep percolation and upward flux. This entails another independent study since we need to have the measured data from the NIS sites covered to enable to undertake a ground water balance to estimate infiltration or recharge rates. We propose that this can be included as one of the recommendations for future studies. The ground water potential maps for the different NIS in Luzon, Visayas and Mindanao are presented in Annex C.

Moreover, another interesting output of GIS mapping is the 3D map as presented in Figure 55. The 3D map presented location of service area of NIS as well as its watershed. Merging this with other maps will be an excellent tool for policy and planning. For example, an input of an update built-up areas or land use plan may show areas for expansion or limits for the irrigated area.

Figure 55. 3D map showing relative elevation of service area and terrain of the whole watershed of the NIS covered in Bukidnon.



5.1.8. Irrigation Performance in terms of Cropping Intensity

Irrigation/cropping Intensity varies from one NIS to another. The cropping intensity of the different NIS cases covered is presented in Figure for the crop years 2005-2017. The highest cropping intensity achieved by a specific NIS is highlighted with red font. The data for Nueva Era RIS, Bonga #2 PIS and Balayungan RIS was not presented. The cropping intensity (in %) per crop year was computed by adding the actual area irrigated during wet and dry cropping divided by FUSA multiplied by 100. Though it is always being interchange as irrigation intensity, the term cropping intensity (CI) will be used in this report.

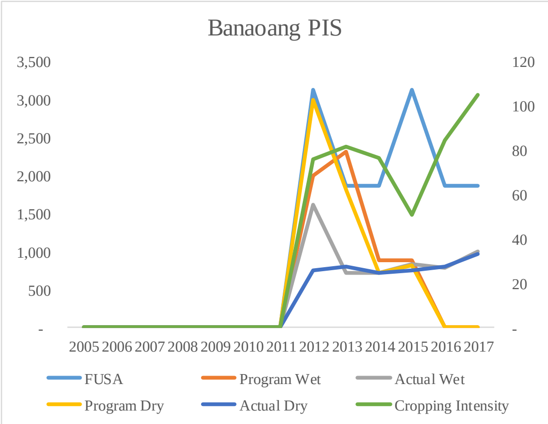
The cropping intensity is one of the basic irrigation performance parameters being used in assessing irrigation systems. Another approach is presented in the succeeding section using the Principal Component Analysis. The best cropping intensity will be 200% or higher, however, this was not always the case. Though CI may vary every year depending on the water flow, condition of the system and other variables, FUSA may also vary every year. FUSA decreases mainly due to land use conversion like housing, commercial expansion, and road development. Other reasons in the reduction of FUSA include conversion to other crops, natural calamity, and not planting of farmers. On the other hand, FUSA increases due to area expansion and system rehabilitation. (Note: The cropping intensity presented in Figure was computed using two cropping only. Some of the NIS have third cropping or other schemes, and may have higher CI presented in their respective reports. Also, some of the NIS in Luzon (Ambayoan-Dipalo RIS) and Mindanao (Padada RIS and Manupali RIS) have other crops being irrigated which may result to higher cropping intensity.)

The average cropping intensity (2005-2017) for the NIS cases ranges from 71% to 205% (Figure 56). The average cropping intensity for Luzon NIS ranges from 71% to 195%. The main reason for the relatively low cropping intensity were siltation and low water supply especially for Pampanga Delta RIS and Caguray RIS. On the other hand, the average cropping intensity for Mindanao NIS ranges from 119% to 205%. The relatively higher cropping intensity especially of South Cotabato NIS may be attributed to high percentage of lined canals and the synchronized scheduling.

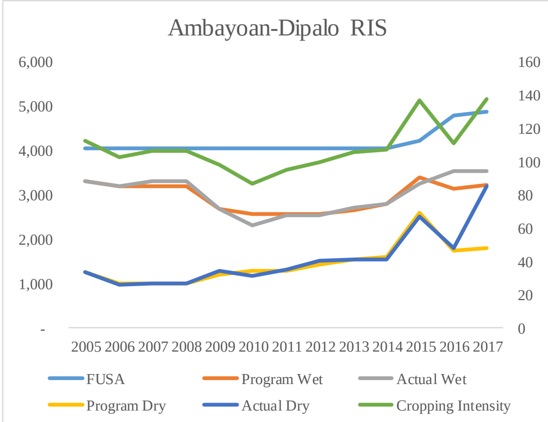
The cropping intensities by the pump irrigation systems (Banaoang and Libmanan-Cabusao) were among the lowest. The performance of large reservoir-type system (MARIIS and UPRIIS) was relatively higher than the smaller one (Bohol NIS).

Figure 56. Firmed-Up Service Area (FUSA), Program and Actual Irrigated Areas (Wet and Dry) and Cropping Intensities of Different NIS covered in (a) Luzon, (b) Visayas, and (c) Mindanao.

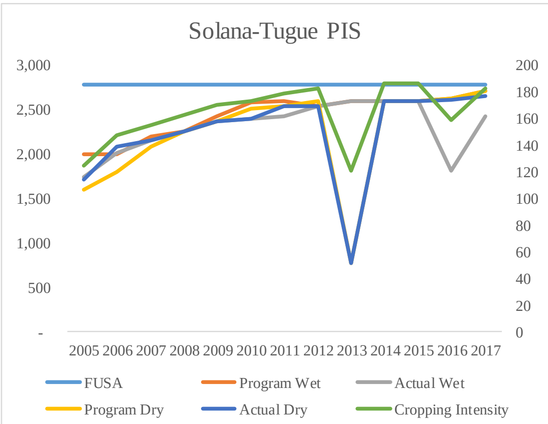
Banaoang PIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012	3,127	2,000	1,620	3,000	750	76
2013	1,873	2,311	720	1,812	810	82
2014	1,873	885	721	725	712	77
2015	3,127	885	841	815	758	51
2016	1,873		783		801	85
2017	1,873		995		970	105
					AVE	**79**



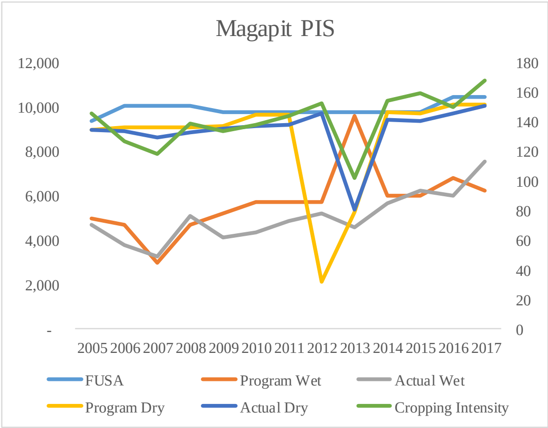
Ambayoan-Dipalo RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	4,045	3,310	3,310	1,240	1,240	112
2006	4,045	3,200	3,200	1,000	959	103
2007	4,045	3,200	3,313	1,000	998	107
2008	4,045	3,200	3,310	1,000	1,000	107
2009	4,045	2,680	2,680	1,200	1,271	98
2010	4,045	2,565	2,320	1,275	1,170	86
2011	4,045	2,565	2,525	1,270	1,323	95
2012	4,045	2,565	2,527	1,435	1,501	100
2013	4,045	2,650	2,715	1,545	1,545	105
2014	4,045	2,800	2,805	1,590	1,526	107
2015	4,209	3,380	3,261	2,600	2,508	137
2016	4,799	3,133	3,532	1,745	1,786	111
2017	4,882	3,208	3,536	1,781	3,187	138
					AVE	**108**



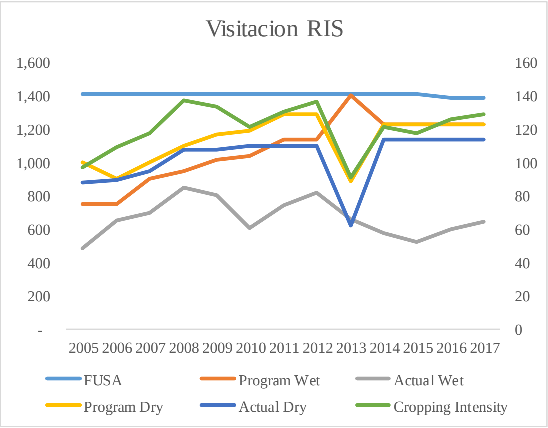
Solana-Tugue PIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,777	2,000	1,735	1,600	1,712	124
2006	2,777	2,000	2,015	1,800	2,081	147
2007	2,777	2,200	2,154	2,080	2,150	155
2008	2,777	2,249	2,249	2,249	2,249	162
2009	2,777	2,424	2,364	2,364	2,364	170
2010	2,777	2,574	2,400	2,514	2,400	173
2011	2,777	2,599	2,425	2,539	2,539	179
2012	2,777	2,539	2,539	2,599	2,539	183
2013	2,777	2,589	2,589	771	771	121
2014	2,777	2,589	2,589	2,589	2,590	187
2015	2,777	2,589	2,590	2,589	2,590	187
2016	2,777	2,619	1,810	2,619	2,605	159
2017	2,777	2,704	2,418	2,704	2,646	182
					AVE	**164**



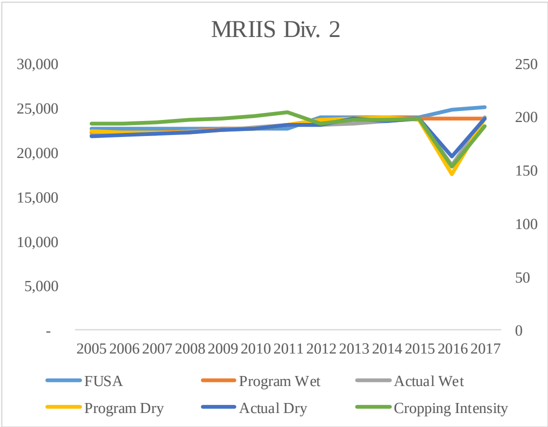
Magapit PIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	9,390	4,975	4,706	8,994	8,949	145
2006	10,046	4,706	3,791	9,084	8,924	127
2007	10,046	3,000	3,269	9,084	8,635	118
2008	10,044	4,706	5,073	9,078	8,872	139
2009	9,787	5,223	4,107	9,145	9,005	134
2010	9,787	5,708	4,375	9,630	9,148	138
2011	9,787	5,718	4,858	9,640	9,200	144
2012	9,791	5,708	5,200	2,104	9,700	152
2013	9,791	9,607	4,599	5,278	5,362	102
2014	9,791	6,000	5,644	9,760	9,421	154
2015	9,791	6,000	6,204	9,691	9,394	159
2016	10,460	6,827	5,998	10,091	9,716	150
2017	10,467	6,203	7,534	10,098	10,026	168
					AVE	**141**



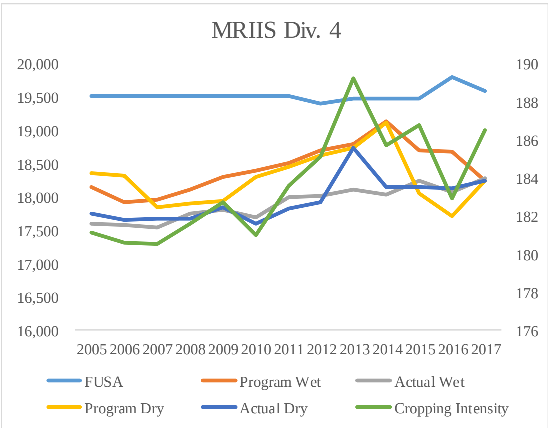
Visitacion RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,409	750	485	1,000	878	97
2006	1,409	750	650	900	891	109
2007	1,409	900	700	1,000	951	117
2008	1,409	950	850	1,100	1,080	137
2009	1,409	1,017	800	1,167	1,080	133
2010	1,409	1,042	605	1,192	1,100	121
2011	1,409	1,140	740	1,290	1,100	131
2012	1,409	1,140	820	1,290	1,100	136
2013	1,409	1,400	662	883	623	91
2014	1,409	1,225	573	1,225	1,140	122
2015	1,409	1,225	518	1,225	1,140	118
2016	1,385	1,225	599	1,225	1,140	126
2017	1,385	1,225	643	1,225	1,140	129
					AVE	**120**



MRIIS Division 2						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	22,676	22,250	21,960	22,411	21,808	193
2006	22,676	22,250	22,047	22,250	21,974	194
2007	22,676	22,250	22,118	22,250	22,070	195
2008	22,676	22,361	22,361	22,281	22,270	197
2009	22,676	22,610	22,474	22,474	22,474	198
2010	22,676	22,676	22,812	22,676	22,676	201
2011	22,676	23,118	23,118	23,118	23,118	204
2012	23,926	23,706	23,105	23,706	23,105	193
2013	23,926	23,816	23,258	23,816	23,816	197
2014	23,926	23,891	23,568	23,871	23,560	197
2015	23,926	23,770	23,774	23,720	23,733	199
2016	24,771	23,860	18,502	17,500	19,500	153
2017	25,011	23,775	23,903	23,744	23,844	191
					AVE	**193**

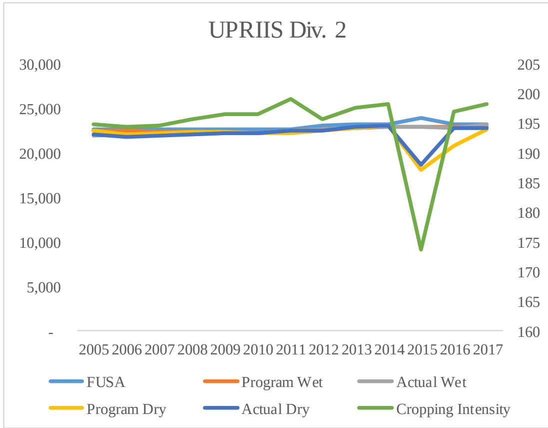


MRIIS Division 4						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	19,512	18,146	17,600	18,368	17,746	181
2006	19,512	17,934	17,592	18,320	17,654	181
2007	19,512	17,959	17,549	17,853	17,682	181
2008	19,512	18,121	17,753	17,914	17,685	182
2009	19,512	18,306	17,814	17,951	17,841	183
2010	19,512	18,400	17,704	18,306	17,610	181
2011	19,512	18,507	17,993	18,464	17,832	184
2012	19,414	18,700	18,017	18,627	17,925	185
2013	19,483	18,803	18,123	18,745	18,745	189
2014	19,483	19,143	18,043	19,114	18,147	186
2015	19,483	18,700	18,240	18,058	18,148	187
2016	19,800	18,682	18,086	17,715	18,137	183
2017	19,594	18,249	18,290	18,247	18,253	187
					AVE	**184**



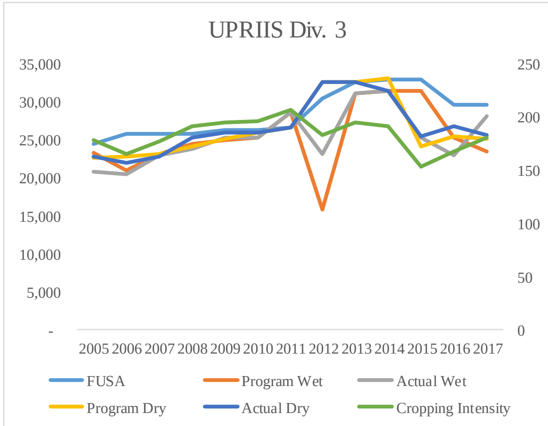
UPRIIS Division 2

CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	22,591	22,500	21,963	22,500	22,036	195
2006	22,591	22,500	22,079	22,036	21,829	194
2007	22,591	22,400	22,103	22,200	21,882	195
2008	22,591	22,334	22,117	22,323	22,099	196
2009	22,591	22,427	22,245	22,323	22,166	197
2010	22,591	22,246	22,246	22,256	22,178	197
2011	22,591	22,473	22,473	22,256	22,501	199
2012	23,098	22,676	22,676	22,501	22,547	196
2013	23,163	22,856	22,856	22,726	22,903	198
2014	23,163	22,897	22,885	23,038	23,038	198
2015	24,008	22,991	22,967	18,033	18,706	174
2016	23,163	22,967	22,752	20,860	22,861	197
2017	23,163	22,967	23,163	22,718	22,773	198
					AVE	**195**



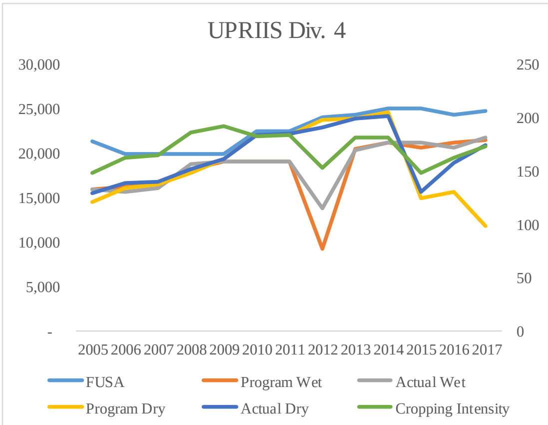
UPRIIS Division 3

CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	24,449	23,300	20,738	22,655	22,806	178
2006	25,738	21,019	20,465	22,810	21,944	165
2007	25,738	23,060	22,990	23,060	22,717	178
2008	25,738	24,427	23,850	24,050	25,301	191
2009	26,211	24,904	25,232	25,072	25,970	195
2010	26,211	25,293	25,293	25,970	25,994	196
2011	26,691	28,660	28,660	26,571	26,571	207
2012	30,527	15,833	23,128	32,687	32,687	183
2013	32,687	31,129	31,129	32,687	32,687	195
2014	32,970	31,509	31,509	33,067	31,516	191
2015	32,970	31,509	25,231	24,065	25,485	154
2016	29,662	25,304	22,925	25,480	26,815	168
2017	29,662	23,520	28,051	25,121	25,643	181
					AVE	**183**



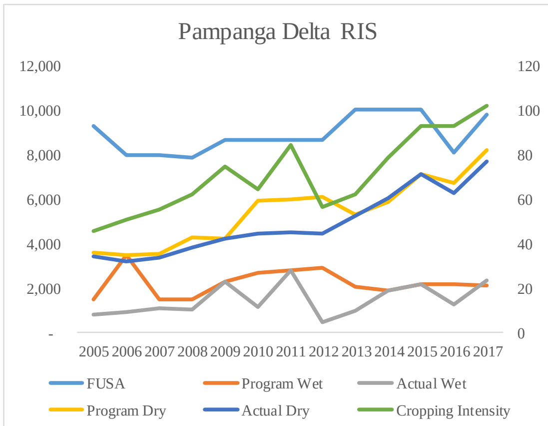
UPRIIS Division 4

CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	21,293	15,900	15,900	14,500	15,540	148
2006	19,924	16,200	15,601	16,000	16,633	162
2007	19,924	16,500	16,009	16,500	16,806	165
2008	19,924	18,139	18,800	17,803	18,186	186
2009	19,924	19,000	19,014	19,276	19,308	192
2010	22,504	19,000	19,008	22,000	22,021	182
2011	22,504	19,100	19,107	22,000	22,214	184
2012	24,080	9,209	13,816	23,811	22,854	152
2013	24,307	20,450	20,277	23,843	23,843	182
2014	24,977	21,220	21,244	24,613	24,179	182
2015	24,977	20,608	21,244	14,864	15,591	147
2016	24,349	21,243	20,682	15,600	18,893	163
2017	24,706	21,403	21,768	11,773	20,833	172
					AVE	**170**

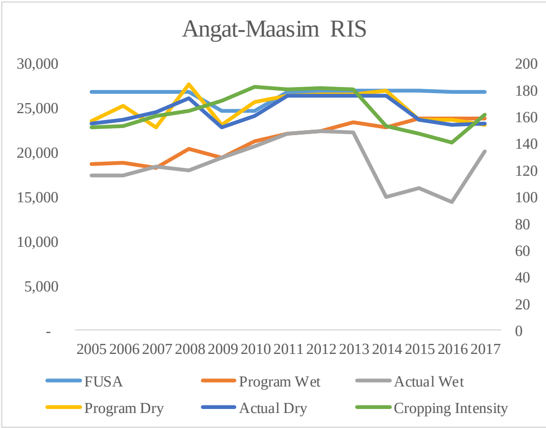


Pampanga Delta RIS

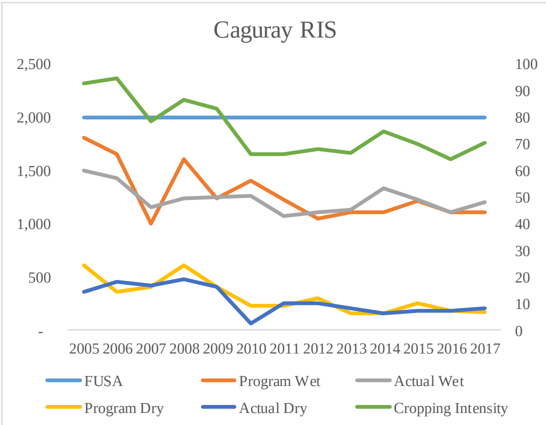
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	9,303	1,502	820	3,603	3,424	46
2006	7,985	3,455	893	3,455	3,162	51
2007	7,985	1,485	1,089	3,543	3,347	56
2008	7,837	1,500	1,042	4,289	3,838	62
2009	8,637	2,253	2,253	4,195	4,195	75
2010	8,637	2,701	1,116	5,898	4,424	64
2011	8,637	2,789	2,789	5,968	4,503	84
2012	8,637	2,889	433	6,086	4,417	56
2013	10,020	2,022	965	5,322	5,248	62
2014	10,020	1,870	1,870	5,848	6,029	79
2015	10,020	2,170	2,170	7,146	7,146	93
2016	8,103	2,173	1,268	6,716	6,244	93
2017	9,812	2,121	2,320	8,227	7,677	102
					AVE	**71**



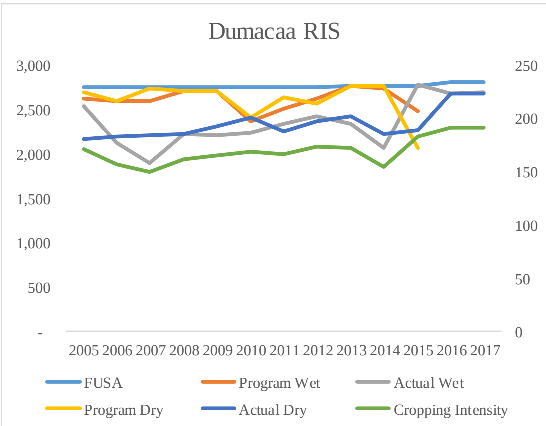
Angat-Maasim RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	26,791	18,718	17,428	23,529	23,240	152
2006	26,791	18,742	17,317	25,163	23,625	153
2007	26,791	18,178	18,396	22,794	24,504	160
2008	26,791	20,356	17,930	27,658	26,071	164
2009	24,593	19,446	19,446	23,013	22,868	172
2010	24,593	21,181	20,648	25,628	24,111	182
2011	26,791	22,108	22,105	26,328	26,328	181
2012	26,791	22,322	22,381	26,545	26,328	182
2013	26,981	23,376	22,296	26,437	26,328	180
2014	26,981	22,846	14,891	26,878	26,383	153
2015	26,981	23,750	15,971	23,667	23,667	147
2016	26,734	23,750	14,423	23,667	23,068	140
2017	26,734	23,750	20,027	23,068	23,182	162
					AVE	**164**



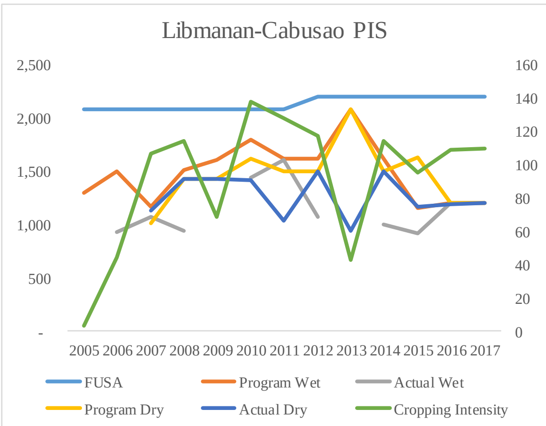
Caguray RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,990	1,800	1,490	600	350	92
2006	1,990	1,650	1,427	350	450	94
2007	1,990	1,000	1,147	409	412	78
2008	1,990	1,600	1,237	600	480	86
2009	1,990	1,230	1,250	400	400	83
2010	1,990	1,400	1,256	220	56	66
2011	1,990	1,226	1,070	220	248	66
2012	1,990	1,050	1,100	300	250	68
2013	1,990	1,100	1,122	150	200	66
2014	1,990	1,100	1,331	150	150	74
2015	1,990	1,213	1,220	250	172	70
2016	1,990	1,100	1,100	180	180	64
2017	1,990	1,100	1,200	170	200	70
					AVE	**75**



Dumacaa RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,752	2,630	2,543	2,690	2,174	171
2006	2,752	2,600	2,127	2,600	2,199	157
2007	2,752	2,590	1,893	2,736	2,217	149
2008	2,752	2,712	2,219	2,712	2,218	161
2009	2,752	2,712	2,216	2,712	2,317	165
2010	2,752	2,363	2,244	2,409	2,409	169
2011	2,752	2,507	2,339	2,632	2,255	167
2012	2,752	2,619	2,421	2,564	2,361	174
2013	2,766	2,766	2,344	2,766	2,420	172
2014	2,769	2,734	2,068	2,769	2,223	155
2015	2,766	2,480	2,784	2,062	2,273	183
2016	2,816		2,687		2,687	191
2017	2,816		2,694		2,687	191
					AVE	**170**



Libmanan-Cabusao PIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,076	1,300		1,520	65	3
2006	2,076	1,500	924			45
2007	2,076	1,172	1,070	1,010	1,136	106
2008	2,076	1,510	940	1,424	1,424	114
2009	2,076	1,610		1,424	1,424	69
2010	2,076	1,800	1,445	1,613	1,421	138
2011	2,076	1,613	1,606	1,500	1,042	128
2012	2,195	1,613	1,076	1,500	1,503	117
2013	2,195	2,076		2,076	940	43
2014	2,195	1,613	1,002	1,500	1,503	114
2015	2,195	1,150	920	1,635	1,171	95
2016	2,195	1,204	1,204	1,204	1,187	109
2017	2,195	1,204	1,204	1,204	1,204	110
					AVE	**92**



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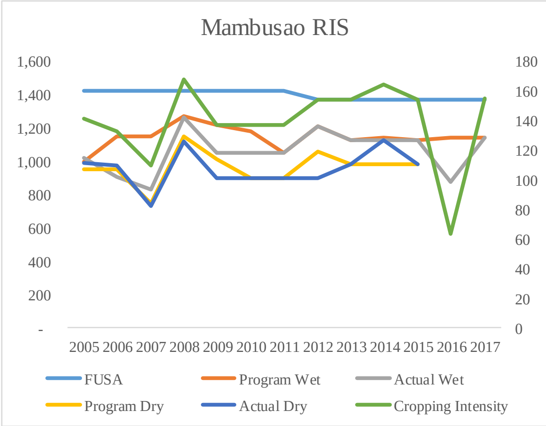
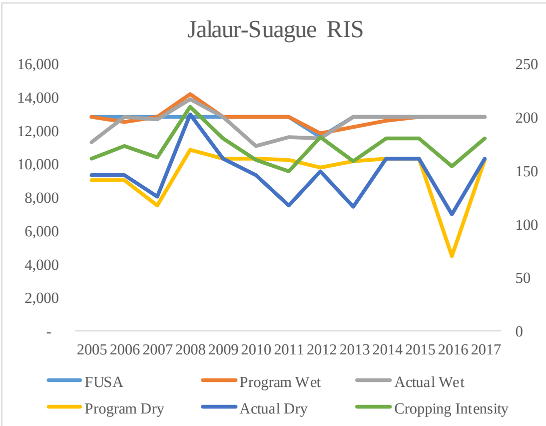
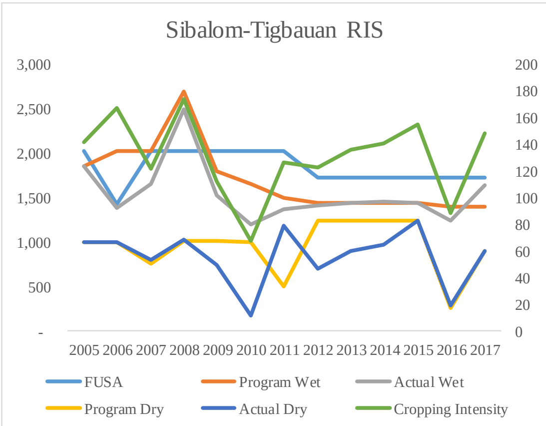
Mambusao RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,420	1,000	1,019	950	988	141
2006	1,420	1,150	910	950	977	133
2007	1,420	1,150	830	750	730	110
2008	1,420	1,270	1,264	1,150	1,119	168
2009	1,420	1,216	1,050	1,016	900	137
2010	1,420	1,180	1,050	900	900	137
2011	1,420	1,050	1,050	900	900	137
2012	1,372	1,210	1,210	1,060	900	154
2013	1,372	1,130	1,130	980	980	154
2014	1,372	1,146	1,130	980	1,130	165
2015	1,372	1,130	1,130	980	980	154
2016	1,372	1,146	874			64
2017	1,372	1,146	1,146	980	980	155
					AVE	**139**



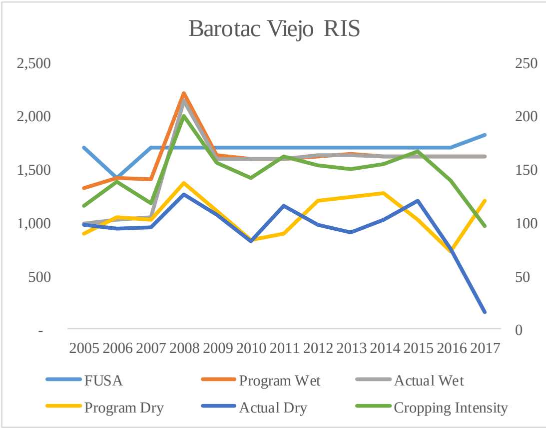
Jalaur-Suague RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	12,790	12,810	11,319	9,000	9,318	161
2006	12,790	12,500	12,788	9,000	9,310	173
2007	12,790	12,789	12,689	7,460	7,995	162
2008	12,790	14,190	13,894	10,815	12,965	210
2009	12,790	12,790	12,790	10,278	10,296	181
2010	12,790	12,780	11,084	10,280	9,343	160
2011	12,790	12,789	11,590	10,208	7,500	149
2012	11,590	11,818	11,489	9,754	9,536	181
2013	12,790	12,210	12,790	10,145	7,455	158
2014	12,790	12,584	12,790	10,289	10,289	180
2015	12,790	12,790	12,790	10,289	10,279	180
2016	12,789	12,790	12,790	4,456	6,962	154
2017	12,789	12,790	12,790	10,269	10,289	180
					AVE	**172**



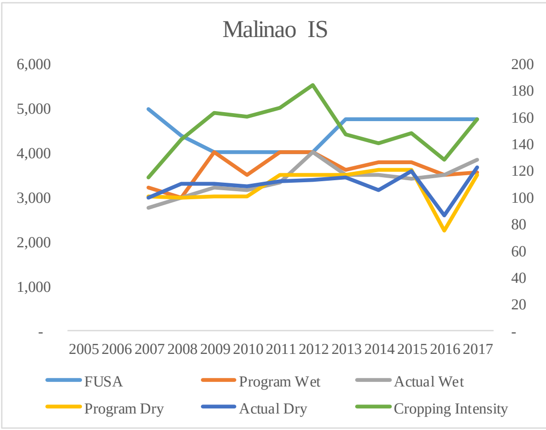
Sibalom-Tigbauan RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,019	1,850	1,850	1,000	1,000	141
2006	1,420	2,019	1,375	1,000	1,000	167
2007	2,019	2,019	1,650	750	800	121
2008	2,019	2,695	2,493	1,015	1,026	174
2009	2,019	1,800	1,520	1,017	738	112
2010	2,019	1,650	1,200	1,000	167	68
2011	2,019	1,500	1,369	500	1,178	126
2012	1,719	1,441	1,404	1,240	700	122
2013	1,719	1,434	1,434	1,233	900	136
2014	1,719	1,434	1,446	1,233	973	141
2015	1,719	1,434	1,434	1,233	1,233	155
2016	1,719	1,400	1,234	256	281	88
2017	1,719	1,400	1,642	900	900	148
					AVE	**131**



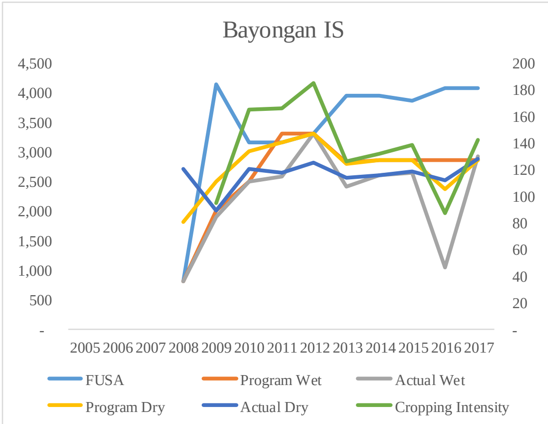
Barotac Viejo RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,700	1,325	988	900	975	115
2006	1,420	1,420	1,028	1,050	937	138
2007	1,700	1,400	1,050	1,030	949	118
2008	1,700	2,210	2,141	1,364	1,262	200
2009	1,700	1,633	1,589	1,113	1,071	156
2010	1,700	1,600	1,599	840	818	142
2011	1,700	1,600	1,599	900	1,151	162
2012	1,700	1,617	1,627	1,208	982	153
2013	1,700	1,642	1,630	1,233	911	149
2014	1,700	1,616	1,616	1,278	1,024	155
2015	1,700	1,616	1,616	1,024	1,208	166
2016	1,700	1,616	1,616	729	756	140
2017	1,825	1,616	1,616	1,208	152	97
					AVE	**146**



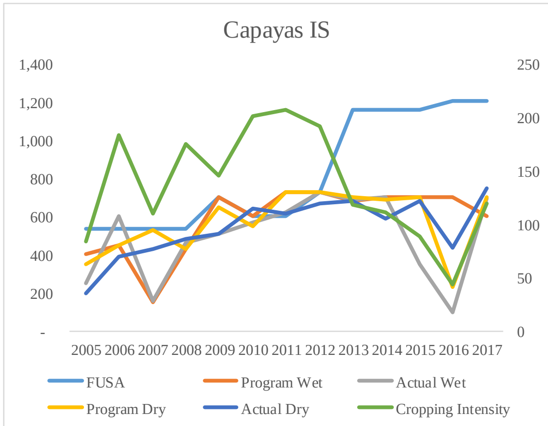
Malinao IS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005						
2006						
2007	4,973	3,200	2,748	3,000	2,968	115
2008	4,387	2,968	2,968	2,968	3,304	143
2009	4,000	4,000	3,218	3,000	3,300	163
2010	4,000	3,500	3,166	3,000	3,244	160
2011	4,000	4,000	3,325	3,500	3,356	167
2012	4,000	4,000	4,000	3,500	3,368	184
2013	4,740	3,600	3,492	3,500	3,452	146
2014	4,740	3,780	3,500	3,600	3,149	140
2015	4,740	3,780	3,402	3,600	3,589	147
2016	4,740	3,500	3,499	2,250	2,573	128
2017	4,740	3,550	3,841	3,500	3,662	158
					AVE	**150**



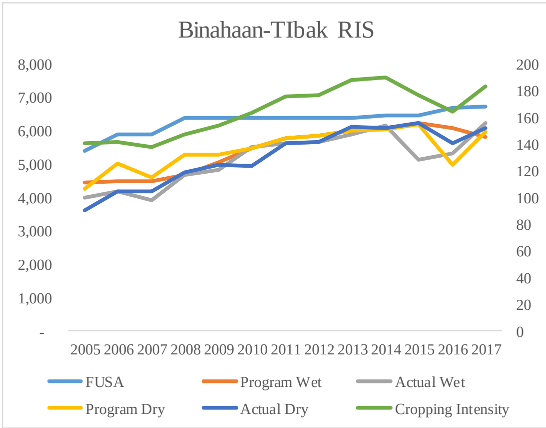
Bayongan IS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005						
2006						
2007						
2008	800	800	800	1,800	2,700	
2009	4,140	2,000	1,900	2,500	2,000	94
2010	3,153	2,500	2,500	3,000	2,700	165
2011	3,153	3,295	2,586	3,153	2,644	166
2012	3,295	3,295	3,295	3,300	2,809	185
2013	3,955	2,810	2,405	2,800	2,566	126
2014	3,955	2,858	2,603	2,858	2,602	132
2015	3,855	2,858	2,650	2,858	2,669	138
2016	4,084	2,858	1,040	2,375	2,510	87
2017	4,084	2,858	2,922	2,858	2,877	142
					AVE	**137**



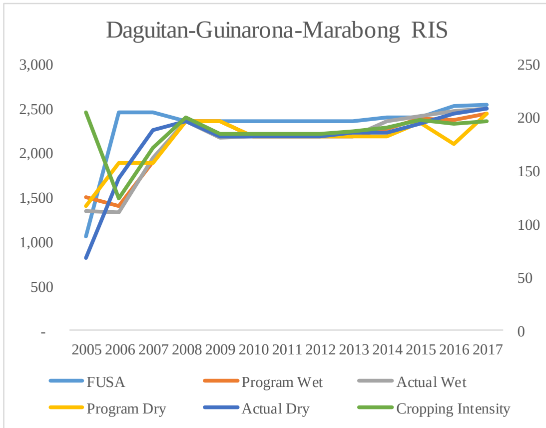
Capayas IS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	539	400	250	350	200	83
2006	539	450	600	450	392	184
2007	539	150	157	530	433	109
2008	539	433	461	433	486	176
2009	700	700	511	650	511	146
2010	600	600	568	550	642	202
2011	600	730	624	730	617	207
2012	730	730	730	730	672	192
2013	1,160	680	687	700	680	118
2014	1,160	700	700	690	592	111
2015	1,160	700	350	700	680	89
2016	1,210	700	98	230	435	44
2017	1,210	600	694	700	746	119
					AVE	**137**



Binahaan-Tibak RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	5,391	4,450	4,002	4,250	3,600	141
2006	5,906	4,500	4,171	5,000	4,176	141
2007	5,906	4,468	3,921	4,614	4,190	137
2008	6,394	4,665	4,665	5,300	4,750	147
2009	6,394	5,038	4,835	5,281	4,981	154
2010	6,394	5,489	5,498	5,489	4,934	163
2011	6,394	5,788	5,613	5,788	5,621	176
2012	6,394	5,834	5,673	5,834	5,654	177
2013	6,394	5,986	5,906	6,000	6,129	188
2014	6,444	6,061	6,159	6,034	6,077	190
2015	6,444	6,240	5,135	6,186	6,226	176
2016	6,672	6,072	5,332	4,981	5,633	164
2017	6,722	5,830	6,245	5,968	6,081	183
					AVE	**165**

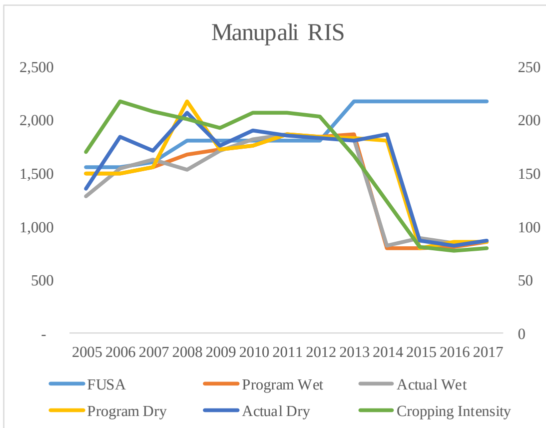


Daguitan-Guinarona-Marabong RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,057	1,496	1,349	1,396	820	205
2006	2,458	1,400	1,333	1,890	1,717	124
2007	2,458	1,900	1,946	1,890	2,262	171
2008	2,362	2,362	2,362	2,362	2,362	200
2009	2,362	2,362	2,171	2,362	2,182	184
2010	2,362	2,182	2,182	2,182	2,182	185
2011	2,362	2,182	2,182	2,182	2,182	185
2012	2,362	2,182	2,182	2,182	2,182	185
2013	2,362	2,182	2,182	2,182	2,226	187
2014	2,405	2,277	2,351	2,182	2,226	190
2015	2,405	2,379	2,414	2,337	2,326	197
2016	2,527	2,371	2,464	2,093	2,438	194
2017	2,548	2,441	2,498	2,441	2,498	196
					AVE	**185**

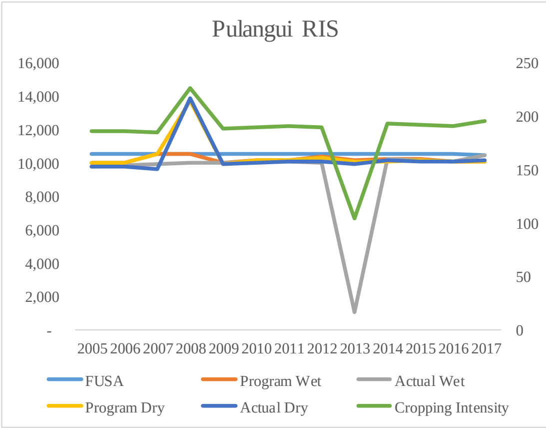


(b)

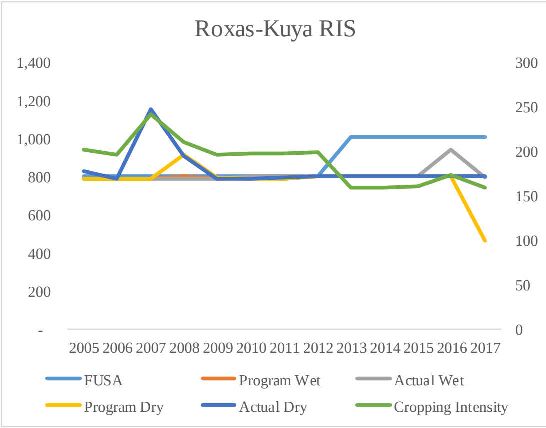
Manupali RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,554	1,500	1,287	1,500	1,356	170
2006	1,554	1,500	1,543	1,500	1,836	217
2007	1,600	1,550	1,621	1,550	1,712	208
2008	1,800	1,674	1,537	2,171	2,070	200
2009	1,800	1,725	1,713	1,725	1,754	193
2010	1,800	1,759	1,816	1,759	1,902	207
2011	1,800	1,868	1,865	1,868	1,851	206
2012	1,800	1,835	1,833	1,835	1,830	204
2013	2,170	1,870	1,813	1,825	1,804	167
2014	2,170	795	820	1,810	1,865	124
2015	2,170	800	888	800	871	81
2016	2,170	805	843	850	823	77
2017	2,170	850	860	860	872	80
					AVE	**164**



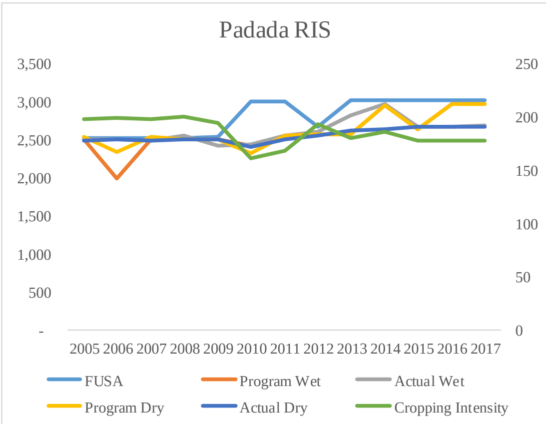
Pulangui RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	10,557	10,000	9,810	10,000	9,812	186
2006	10,557	10,000	9,819	10,000	9,782	186
2007	10,557	10,557	9,902	10,557	9,647	185
2008	10,557	10,557	10,037	13,694	13,863	226
2009	10,557	10,019	10,019	9,924	9,924	189
2010	10,557	10,185	10,054	10,187	9,984	190
2011	10,557	10,187	10,063	10,185	10,064	191
2012	10,557	10,350	9,982	10,300	10,054	190
2013	10,557	10,175	1,053	10,050	9,942	104
2014	10,557	10,200	10,200	10,100	10,184	193
2015	10,557	10,200	10,167	10,150	10,100	192
2016	10,557	10,100	10,105	10,100	10,087	191
2017	10,550	10,100	10,462	10,100	10,194	196
					AVE	**186**



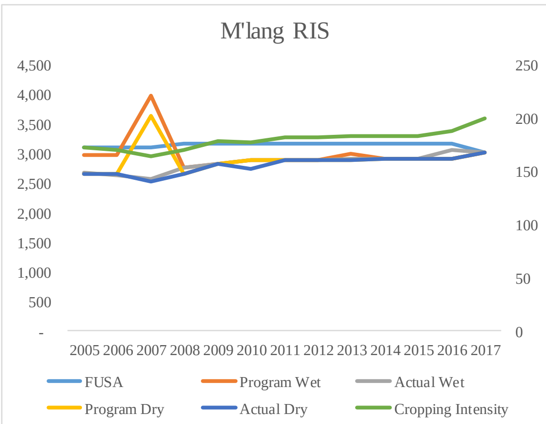
Roxas-Kuya RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	805	790	791	790	829	201
2006	805	790	790	790	787	196
2007	805	790	787	790	1,158	242
2008	805	800	790	912	907	211
2009	805	790	790	795	790	196
2010	805	795	802	790	790	198
2011	805	790	802	790	794	198
2012	805	800	802	800	802	199
2013	1,006	802	802	802	801	159
2014	1,006	802	802	802	802	159
2015	1,006	802	804	802	804	160
2016	1,006	804	939	804	804	173
2017	1,006	805	793	462	804	159
					AVE	**189**



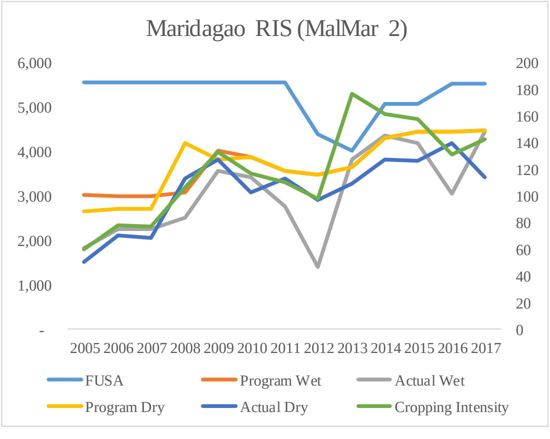
Padada RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,515	2,511	2,500	2,537	2,491	198
2006	2,515	1,994	2,499	2,339	2,500	199
2007	2,515	2,511	2,486	2,537	2,493	198
2008	2,515	2,510	2,550	2,510	2,500	201
2009	2,532	2,502	2,421	2,502	2,501	194
2010	3,010	2,420	2,441	2,321	2,400	161
2011	3,010	2,554	2,554	2,554	2,509	168
2012	2,675	2,572	2,602	2,574	2,558	193
2013	3,015	2,572	2,821	2,574	2,621	180
2014	3,015	2,955	2,967	2,955	2,633	186
2015	3,015	2,643	2,670	2,634	2,670	177
2016	3,015	2,965	2,672	2,965	2,672	177
2017	3,015	2,965	2,687	2,965	2,677	178
					AVE	**185**



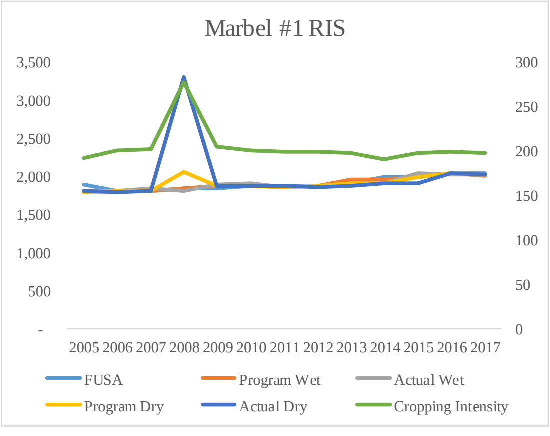
M'lang RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	3,108	2,981	2,685	2,650	2,661	172
2006	3,100	2,981	2,631	2,650	2,650	170
2007	3,100	3,981	2,565	3,650	2,519	164
2008	3,177	2,769	2,769	2,650	2,650	171
2009	3,177	2,835	2,835	2,835	2,835	178
2010	3,177	2,900	2,885	2,885	2,747	177
2011	3,177	2,885	2,885	2,885	2,885	182
2012	3,177	2,885	2,887	2,885	2,885	182
2013	3,177	3,005	2,916	2,885	2,901	183
2014	3,177	2,916	2,918	2,916	2,916	184
2015	3,177	2,918	2,918	2,918	2,918	184
2016	3,177	2,918	3,058	2,918	2,918	188
2017	3,018	3,018	3,018	3,018	3,018	200
					AVE	**180**



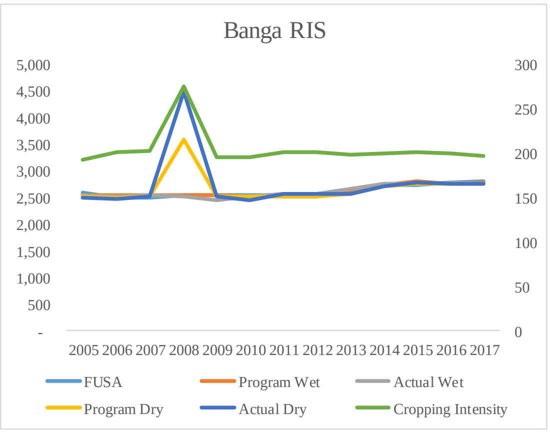
Maridagao RIS (MalMar 2)						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	5,562	3,006	1,817	2,641	1,520	60
2006	5,562	3,000	2,247	2,700	2,109	78
2007	5,562	3,000	2,249	2,700	2,050	77
2008	5,562	3,085	2,508	4,190	3,400	106
2009	5,562	4,004	3,548	3,829	3,829	133
2010	5,562	3,869	3,415	3,869	3,069	117
2011	5,562	3,560	2,771	3,560	3,383	111
2012	4,399	3,482	1,399	3,482	2,896	98
2013	4,027	3,651	3,831	3,651	3,274	176
2014	5,068	4,304	4,369	4,304	3,806	161
2015	5,068	4,433	4,202	4,433	3,788	158
2016	5,527	4,433	3,062	4,433	4,191	131
2017	5,527	4,482	4,452	4,482	3,418	142
					AVE	**119**



Marbel #1 RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	1,885	1,788	1,807	1,788	1,798	191
2006	1,802	1,806	1,809	1,798	1,796	200
2007	1,802	1,806	1,844	1,798	1,801	202
2008	1,842	1,841	1,813	2,051	3,307	278
2009	1,842	1,868	1,881	1,868	1,878	204
2010	1,878	1,878	1,898	1,865	1,879	201
2011	1,878	1,859	1,853	1,859	1,879	199
2012	1,878	1,865	1,873	1,865	1,863	199
2013	1,913	1,950	1,902	1,905	1,871	197
2014	1,994	1,950	1,904	1,900	1,905	191
2015	1,994	1,995	2,039	1,995	1,904	198
2016	2,046	2,042	2,027	2,039	2,042	199
2017	2,042	2,013	2,018	2,015	2,019	198
					AVE	**204**



Banga RIS						
CY	FUSA	Program Wet	Actual Wet	Program Dry	Actual Dry	Cropping Intensity
2005	2,607	2,542	2,541	2,534	2,495	193
2006	2,499	2,541	2,536	2,495	2,487	201
2007	2,499	2,542	2,539	2,534	2,520	202
2008	2,546	2,539	2,525	3,590	4,494	276
2009	2,546	2,539	2,451	2,535	2,514	195
2010	2,546	2,530	2,529	2,530	2,456	196
2011	2,546	2,522	2,565	2,522	2,562	201
2012	2,546	2,530	2,569	2,530	2,575	202
2013	2,635	2,637	2,668	2,567	2,570	199
2014	2,745	2,745	2,765	2,717	2,717	200
2015	2,745	2,799	2,765	2,765	2,780	202
2016	2,780	2,765	2,781	2,765	2,765	199
2017	2,799	2,784	2,763	2,758	2,758	197
					AVE	**205**



(c)

(Source: NISPER 2005-2017)

5.1.9. Other Technical Issue: Canal Operation and Maintenance

Bench Flume. Most of the visited NIS uses bench flume design (rectangular canal) in the lining of Main and Lateral canals (Photos 90 and 91). Compared to the rectangular cross-section design, rectangular section occupies less space and lesser earthworks making it faster to construct and lower in cost. However, the design section of NIA should look or study the bench flume design in terms of hydraulic efficiency. Flow efficiency is very critical during low water supply. The design should consider a canal discharge level that would need the use of bench flume as canal cross-section.

Photo 90. Section of Main Canal of Visitacion NIS

Photo 91. Section of Lateral G6 of Pulangui RIS.

MAINs Problem? As part of the original design of irrigation systems, the Main and Lateral canals should be lined for the system to have high conveyance efficiencies. These canal carries large volume of water which makes it prone to high seepage and percolation as well as erosion. However, lining or even rehabilitating the Main Canal of an operational NIS pose a very big problem, not only for the operation but also the socio-economic impact. A NIS will cut off water supply for about two months only. In this period, the length for lining or rehabilitation will not be significant. It will take about a year or two to line a significant section of Main Canal of a particular NIS. One could compare this during road repairs of main thorough fares in the Philippines. But, cutting the water supply of a given NIS for one year will affect livelihood of the farmers as well as the target rice yield of the area. For example, if the 21 kms of unlined section of the Main Canal (Photo 92) of Jalaur RIS will be lined, it will affect about 8,200 has of farms in Iloilo. Thorough planning and use of advance construction technology (or methodology) will be needed to properly execute lining of Main Canal. For example, at the time of survey, sections of Main Canal of Padada RIS were being lined (Photo 93). Lining of the Main Canal could pose a problem during operation. A system could only have a water cut off of around two months. In this period, only a small portion could be lined depending on the condition. The lining of the MC of Padada RIS has to be temporarily suspended (Photo 94). However, total system closure for one to two croppings is a bigger problem.

Photo 92. Section of Main Canal, Jalaur Proper RIS that meander.

Photo 93. Unfinished construction of Main canal of Padada RIS.

Photo 94. Unfinished construction of Main canal of Padada RIS near Lateral A.

Lock or Not. In all NIS cases covered, one of the most common problem during operation was the illegal opening of gates (Laterals and turnouts). In some of the NIS surveyed, gates were being padlocked (Photo 95) to avoid illegal opening. While some of the gates were confined and protected with padlocked gates (entrance). But only in some of the NIS surveyed in Mindanao (Photo 96) where gates are being welded (permanent). In fact, Bukidnon IMO was planning in procuring more portable welding machine for this purpose. Padlocks are prone to breakdown and sometimes stolen thus, gates were being welded.

Photo 95. Gate in Cavite FLIS.

Photo 96. Gates in Banga RIS.

Trapped! Some of the floating debris in the Main and Lateral canals were trapped near the checkgates (Photos 97 and 98). However, removal of debris is a big problem with NIS with wide canals like Angat-Maasim RIS, Pampanga Delta RIS, UPRIIS, MARIIS, Libmanan-Cabusao PIS, Binahaan-Tibak RIS, Jalaur RIS and Malitubog-Maridagao RIS. To remove debris in a wide canal section, one may need long poles, a platform to stand during operation and some NIS even uses back hoe equipment.

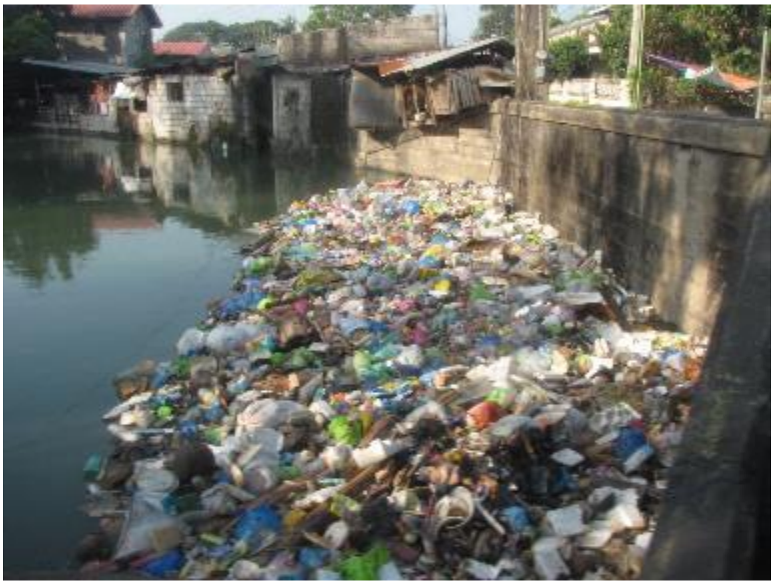


Photo 97. Section of Main Canal of Angat-Maasim RIS.

Photo 98. Debris trapped in a check gate along Main Canal of Malitubog-Maridagao RIS.

Innovations? Some structures in the NIS in Mindanao looks weird, at least at the technical point of view. But this was the adjustments made by people from ground (operations) to cope up with actual situations. For example, Lateral A of Padada RIS has two headgates (Photo 99). Additional (second headgate, Photo 100) gate was installed because water spills on this section during high flows. On the other hand, additional canal was installed beside the existing lined canal of Lateral F, Banga RIS (Photo 101). Additional areas for expansion was added on the tail-end part of Lateral F. This will require increasing the cross-sectional area of canal to accommodate higher discharge rate. To avoid demolition of a part of the existing canal, additional canal was constructed beside it, making it a double canal.

Photo 99. Second headgate of Lateral A of Padada RIS.

Photo 100. First (original) headgate of Lateral A of Padada RIS.

Photo 101. The “double” canal of Lateral F, Banga RIS.

5.2. Results of FGDs and IA Interviews

In this report, only initial findings based on Interviews (KII and FGDs) are discussed in relation to the Institutional/Technical evaluation of the NIS covered.

The team interviewed 151 irrigators association (IAs) from the different National Irrigation System across the country. The IAs was selected to represent upstream, midstream, and downstream sentiment of farmers.

The summary of IA Functionality Survey from 2013 to 2017 is presented in Table 29. Most of the IAs are in the Very Satisfactory and Satisfactory rating. The IAs surveyed in MARIIS and UPRIIS have a rating of Satisfactory to Outstanding.

Table 29. Summary IA Functionality Survey from 2013 to 2017

REGION	Average no. of IA organized	Average no. of IA evaluated	% IA	IA functionality rating average				
				O	VS	S	FAIR	POOR
1	277	242	87.5	10	117	97	16	2
MRIIS	358	355	99.2	126	216	13	0	0
2	174	164	94.2	18	91	53	2	0
UPRIIS	412	394	95.4	191	202	0	0	0
3	300	252	83.9	19	165	65	2	0
4A	88	83	94.3	1	29	40	12	1
4B	112	95	85.5	6	30	47	12	1
5	79	73	91.9	10	29	29	3	2
6	165	161	97.1	2	36	64	46	13
7	84	84	99.5	11	65	8	0	0
8	83	81	97.8	12	36	26	6	1
10	97	83	85.6	11	38	26	9	0
11	128	126	98.0	47	58	19	0	2
12	241	226	93.8	21	110	72	22	1
TOTAL	2599	2418	93.0	483	1221	559	130	24

5.2.1. Technical

The usual problems pertaining to irrigation were asked of the respondents. The top 3 problems elicited from the respondents were: 1) Siltation; 2) Shortage of water due to water schedule or stealing of water (internal); and 3) Shortage of water due to environmental limitation.

Siltation has already been a common problem in the irrigation system. This could be due to natural causes or structural causes. This poses significant threat to the farmers as it further decreases the available water in the system and increases the efficiency losses of the canal. As in NIS cases in Luzon, siltation is also a major concern especially in

Jalaur RIS where the 8-meter-wide main canal have been reduced to a width of 1 meter due to siltation.

Shortage of water due to scheduling or stealing of water is an institutional and organizational issue. This pertains to the effectivity and efficiency of the management of IAs towards their members. Rampant occurrence of water stealing should be supported by institutional policies and strict organizational enforcement. Note that this should not be confused with "shortage due to scheduling brought about by NIA or other agencies". The latter, which gained minimal vote, is merely poor coordination and operation of the irrigation system.

Finally, the third most common problem is shortage of water due to environmental limitation. This is very common among different irrigation systems since many watersheds which produce irrigation water were mismanaged. In effect, some farmers are constructing illegal turnouts to avail of canal water and check dams to elevate water level or use pumps to draw water from the canals. Others adopt drainage water re use by pumping water from creeks.

Other notable common problems of farmers are: canal repair, farm-to-market road, shortage due to engineering limitations and/or design.

Table 30. Problems encountered by farmers related to irrigation

Problems	Luzon	Visayas	Mindanao
Siltation	9	4	16
Solid waste	6	3	5
Canal repair	10	15	6
Earth canal to be lined	7	3	12
Dam repair	1	0	0
Gates for repair	2	3	12
Shortage of water due to environmental limitation	6	18	3
Shortage of water due to engineering limitation	9	5	16
Farm to market road	10	9	9
Shortage of water due to water schedule or stealing of water/institutional cause (internal)	20	64	53
Shortage of water due to water schedule or stealing of water/institutional cause (due to NIA or government)	12	12	40
no answer	13	1	1
Number of responses	105	137	173
Number of respondents	65	48	39

Therefore, given the problems that encountered, the interviewed IAs were inquired of different set of questions pertaining to their satisfaction rate and perception on different technical, economic, and institutional situation and indicator questions which affects their performance.

It was highly regarded by the farmers that NIA provides regular support to the farmers. Majority of the IAs affirmed that they receive regular support of different type. The most common support that NIA provide to the farmers is in terms of technical. This includes providing different types of trainings, seminars, and other consults and advice that would enhance the capability of the farmers in the efficient management of their system. On the other hand, the least common support that NIA provide is in terms of equipment and other physical and structural support. This could be attributed to the limited resources of the organization in providing adequate equipment and other physical support needs.

The IAs were also asked if the group had already made modifications in the irrigation structures provided. Although majority of the IAs did not have any modifications, the few groups that that were asked what modifications were made usually spend it in the lining of earth canals and repair of irrigation infrastructure. Note that the commonality between modifications pertains to addressing siltation. IAs that did not have modifications in their structure, and even those that have already had modifications, mentioned that their main constraint for improving their facilities is due to their financial resource limitation. Furthermore, farmers affirmed some of the observations during the walk-throughs wherein some canal structures in many NIS cases covered are damaged and missing.

Pumps were also used by some members as indicated in Table 31. This is not uncommon since many members experience difficulty in accessing irrigation water even with the assistance of NIA. These were affirmed during the field visits and checking with the groundwater potential map of specific NIS cases. Coping mechanisms by farmers during dry spell or low water supply is presented in Table 32.

The results in Table 31 also indicate that majority of the IAs practice scheduling or rotational irrigation. The usual preferred irrigation flow practiced by the IAs is upstream to downstream which would flow through different irrigation zones. There are usually around 7 irrigation zones per IA which are commonly divided based on their lateral identification. The scheduling of irrigation water is just one of the policies formulated to have equitable and efficient use of the natural resource. Results reflect that the common irrigation flow preference of the IA is from upstream to downstream (Table 33). Although the average rating is still remarkably high, the ratings also decrease from upstream to downstream.

Table 31. Questions related to other modes of irrigation and scheduling

QUESTION	YES	NO	Blank	Total
Is/are there farm(s) within the service are that is/are being irrigated by other modes of irrigation to supplement its/their crop water requirements?	69	46	36	151
If Y, provide details below (Y-pump)	61	10	80	151
Is irrigation scheduling or rotational irrigation practiced for these zones or farm groups?	118	23	10	151

Table 32. Coping strategies adopted by the IA in case of prolonged dry spell

	Count
Proper Monitoring and Scheduling / Rotation	56
Pumps	22
Planting Other Crops	19
AWD/ Water Saving / Rationing	15
None	11
STW/ deep wells	9
Reduce Irrigated Area	8
Cloud Seeding	8
Ratooning/ One Cropping/ Adjust Cropping Calendar	6
No data	40
Total Number of Responses	111

Table 33. Questions related to preferred irrigation flow

QUESTION	U-D	D-U	OTHERS	Blank	Total
Preferred irrigation flow	59	43	6	43	151

(Note: D-U = downstream-upstream; U-D = upstream-downstream)

5.2.2. Economic

Economic profiles of IAs interviewed were also elicited during the KII. Note that the declared profiles are only rough estimates as declared by the IA members or officers interviewed. Commonly, there are only 2 cropping in a year; however, there were IAs that were interviewed claim that they only have 1 cropping season per year and IAs which claimed that they can have as much as 3 cropping seasons per year.

Table 34 shows the average production yield in cavans per hectare by cropping season. Normally, 1st cropping season happens either from June to November. On the other hand, the 2nd cropping usually falls from November to March.

Results show that the highest yield usually falls on the 1st cropping. Overall, the average yield of the IAs reaches up to 110 cavans per hectare (Mindanao) wherein it could go for as low as 40 cavans per hectare and as high as up to 200 cavans per hectare. Since the 2nd cropping usually falls on months with strong rain, normally have the lowest yield at 85 cavans per hectare (Visayas) on the average.

Table 34. Average production yield in cavans per hectare by cropping season

Province	1st cropping (cavans/ha)					2nd cropping (cavans/ha)				
	<40	41-64	65-99	>100	Ave	<40	41-64	65-99	>100	Ave
Luzon										
Quezon	0	0	3	0	87.00	0	0	2	1	90.00
Cavite	0	0	3	0	80.00	0	1	2	0	68.33
Ilocos Norte	0	0	2	1	90.00	0	0	2	1	106.67
Ilocos Sur	0	0	1	3	97.50	0	0	0	4	135.00
Pampanga	0	0	2	2	87.50	0	1	2	2	80.00
Isabela	0	0	0	9	131.11	0	0	1	8	112.78
Nueva Ecija	0	0	1	7	120.00	0	0	6	2	95.00
Bulacan	0	0	1	1	119.00	0	0	0	2	110.00
Cagayan	0	0	3	6	123.89	0	2	1	5	90.63
Occidental Mindoro	0	0	1	2	103.33	1	1	1	0	60.00
Pangasinan	1	0	2	2	91.60	0	1	2	1	80.00
Tarlac	0	0	1	2	106.67	0	0	0	3	130.00
Camarines Sur	0	0	2	1	86.67	0	1	2	0	76.67
Total no. of IA's	1	0	22	36	101.87	1	7	21	29	95.01
%	1.69	0.00	37.29	61.02		1.72	12.07	36.21	50.00	
Visayas										
Bohol	0	0	9	5	94.71	0	0	6	8	100.71
Leyte	0	0	5	7	101.07	0	0	10	2	90.81
Iloilo	0	0	12	5	93.61	0	1	12	4	85.68
Capiz	0	3	2	0	63.80	0	1	2	0	63.79
Total no. of IA's	0	3	28	17	88.30	0	2	30	14	85.25
%	0.00	6.25	58.33	35.42		0.00	4.35	65.22	30.43	
Mindanao										
Davao del Sur	0	0	0	5	132.00	0	0	0	5	129.60
North Cotabato	0	0	2	4	103.20	0	0	2	4	104.27

Province	1st cropping (cavans/ha)					2nd cropping (cavans/ha)				
	<40	41-64	65-99	>100	Ave	<40	41-64	65-99	>100	Ave
South Cotabato	0	0	3	9	106.23	0	0	7	4	96.57
Maguindanao	0	0	2	0	91.80	0	0	1	1	109.80
Bukidnon	0	0	7	7	118.79	0	0	6	8	111.38
Total no. of IA's	0	0	14	25	110.40	0	0	16	22	110.32
%	0.00	0.00	35.90	64.10		0.00	0.00	42.11	57.89	

(Note: All data were adjusted to 50 kg/cavan)

The farmers were also requested to provide their production profit and costs. Tables 35 and 36 shows the profit and costs profile both for 1st and 2nd cropping.

During the 1st cropping season, the overall production cost per hectare reaches PhP 33,550 (Luzon) while the gross profit, would reach up to PhP 80,685.07 per hectare (Mindanao). On the other hand, during 2nd cropping, the average overall production cost reaches PhP 32,300 (Luzon) while the average gross profit per hectare usually reaches PhP 85,797.97 (Mindanao).

Based on the IAs interviews and FGDs, there is a wide range in the financial performance of IAS in terms of net profit from production. The area of landholding ranges from 1 to 2 ha, the harvest ranges from 80 to 180 cavans per hectare, the content range from 42 to 60 kg per cavan and the selling price ranges from PhP 12 to 21 per kg. Based on this, the Gross profit ranges from PhP 43,200 per ha (Mambusao, Capiz NIS) to PhP 81,600 per ha (Bayongan, Bohol NIS) With production costs ranging from PhP 27,000 (Mambusao) to 30,000 (Bayongan), the net profit ranges from PhP 16,000 per ha (Mambusao) to 51,600 per ha (Bayongan). This varying financial performance of IAs only shows that some IAs are performing well compared to others. The identified factors affecting performance are higher production/operational costs in some areas, low buying price of palay by NFA/Traders in other areas, and inequitable distribution and delivery of water from upstream to downstream sections of the main canal/lateral.

The main crop that is planted by farmers is rice/palay, but there is also some which plant corn. Other crops planted are garlic, vegetables, watermelon, onion, ginger, mongo, tobacco, peanut, banana, and pineapple.

Table 35. Production, cost and profit of Palay for the 1st cropping

Province	Total production (kg/ha)	Total production cost (PhP/ha)	Gross profit (PhP/ha)	Net profit (PhP/ha)
Luzon				
Quezon	4330.67	₱28,333.33	₱71,621.33	₱43,288.00
Cavite	3666.67	₱30,000.00	₱47,000.00	₱17,000.00
Ilocos Norte	4500.00	₱31,666.67	₱80,500.00	₱48,833.33
Ilocos Sur	4875.00	₱37,500.00	₱85,000.00	₱50,000.00
Pampanga	4375.00	₱20,000.00	₱68,000.00	₱48,000.00
Isabela	6412.22	₱42,777.78	₱106,801.11	₱63,856.67
Nueva Ecija	6518.75	₱46,333.33	₱132,464.29	₱97,300.00
Bulacan	5445.00	₱36,000.00	₱98,010.00	₱62,010.00
Cagayan	6250.00	₱36,250.00	₱110,718.75	₱74,531.25
Occidental Mindoro	5166.67	₱32,333.33	₱87,833.33	₱41,000.00
Pangasinan	4430.00	₱37,500.00	₱81,510.00	₱54,825.00
Tarlac	5666.67	₱30,000.00	₱98,500.00	₱68,500.00
Camarines Sur	4513.33	₱31,666.67	₱74,060.00	₱42,393.33
Average Production Cost		₱33,550.00		
Average Net Profit				₱54,733.66
Visayas				
Bohol	4735.71	₱37,250.00	₱90,287.50	₱52,612.50
Leyte	5053.33	₱31,398.75	₱73,159.00	₱44,200.00
Iloilo	4416.29	₱36,793.33	₱63,593.73	₱32,677.38
Capiz	3190.00	₱25,500.00	₱41,522.50	₱19,323.33
Average Production Cost		₱32,735.52		
Average Net Profit				₱37,203.30
Mindanao				
Davao del Sur	6600.00	₱41,000.00	₱132,000.00	₱82,000.00
North Cotabato	5160.00	₱30,400.00	₱88,840.00	₱82,840.00
South Cotabato	5311.67	₱25,625.00	₱111,126.67	₱95,892.50
Maguindanao	4590.00	₱17,000.00	₱82,530.00	₱68,500.00
Bukidnon	5939.29	₱35,357.14	₱111,692.86	₱74,192.86
Average Production Cost		₱29,876.43		
Average Net Profit				₱80,685.07

Table 36. Production, cost and profit of Palay for the 2nd cropping

Province	Total production (kg/ha)	Total production cost (PhP/ha)	Gross profit (PhP/ha)	Net profit (PhP/ha)
Luzon				
Quezon	4576.67	₱28,333.33	₱68,678.33	₱40,347.67
Cavite	3750.00	₱33,333.33	₱47,875.00	₱14,541.67
Ilocos Norte	5333.33	₱28,333.33	₱85,333.33	₱57,000.00
Ilocos Sur	6750.00	₱35,000.00	₱93,500.00	₱58,500.00
Pampanga	4100.00	₱12,000.00	₱45,000.00	₱33,000.00
Isabela	5350.00	₱42,777.78	₱89,894.44	₱47,116.67
Nueva Ecija	5031.25	₱30,333.33	₱94,000.00	₱66,783.33
Bulacan	7150.00	₱38,000.00	₱128,700.00	₱120,700.00
Cagayan	4687.50	₱35,000.00	₱87,714.29	₱52,714.29
Occidental Mindoro	4000.00	₱32,333.33	₱68,000.00	₱35,666.67
Pangasinan	5125.00	₱32,500.00	₱85,125.00	₱50,625.00
Tarlac	6333.33	₱30,000.00	₱114,666.67	₱84,666.67
Camarines Sur	3973.33	₱31,666.67	₱69,046.67	₱37,380.00
Average Production Cost		₱32,300.00		
Average Net Profit				₱53,772.46
Visayas				
Bohol	5035.71	₱32,857.14	₱92,350.00	₱62,971.43
Leyte	4540.58	₱33,125.00	₱74,443.50	₱40,315.25
Iloilo	4283.82	₱35,746.15	₱64,361.40	₱24,252.92
Capiz	3189.33	₱25,500.00	₱49,082.00	₱26,582.00
Average Production Cost		₱31,807.07		
Average Net Profit				₱38,530.40
Mindanao				
Davao del Sur	6480.00	₱41,000.00	₱138,000.00	₱88,000.00
North Cotabato	5213.33	₱18,200.00	₱97,144.00	₱78,944.00
South Cotabato	4828.27	₱25,625.00	₱107,297.78	₱91,585.00
Maguindanao	5490.00	₱17,000.00	₱99,450.00	₱99,280.00
Bukidnon	5568.93	₱35,357.14	₱106,537.50	₱71,180.36
Average Production Cost		₱27,436.43		
Average Net Profit				₱85,797.87

The team also inquired several questions which is relevant to their economic well-being particularly in terms of the irrigation service fees. The succeeding tables below show the responses of the 151 IAs.

Across the IAs interviewed, there were different estimates declared for the actual ISF that they pay per cropping season and per location. This could be due to exceptions and other arrangements between the farmers and the collection party. Moreover, at the time survey in Visayas and Mindanao, Free Irrigation was being implemented. But still, fees were being collected by IAs (Tables 37 and 38). To avoid confusion and disputes, the "irrigation service fee" was termed as irrigation maintenance fee, association fee, water maintenance, etc. With free irrigation, IAs have no funds to clear the canal and support from NIA is also lacking. They have actually made a resolution asking for heavy equipment for canal clearing.

The water charges that were usually collected in the IAs is presented in Table 38. Before free irrigation, ISF bills are normally prepared by NIA but the actual collection task would depend on the model type of the IA. Usually, NIA collects the ISF but is assisted by the IAs.

Table 37. Fees being collected from farmers by IA

Province	Irrigation service fee	Development cost contribution (DCC)/ amortization	Others
Luzon			
Quezon	3	0	0
Cavite	0	0	3
Ilocos Norte	0	1	1
Ilocos Sur	1	0	3
Pampanga	2	0	1
Isabela	9	0	0
Nueva Ecija	5	0	1
Bulacan	1	0	1
Cagayan	4	0	6
Occidental Mindoro	1	0	1
Pangasinan	4	0	0
Tarlac	3	0	0
Camarines Sur	3	0	0
Visayas			
Bohol	2	0	35
Leyte	0	1	20
Iloilo	0	0	0
Capiz	0	0	0
Mindanao			
Davao del Sur	5	0	2
North Cotabato	0	0	4
South Cotabato	12	0	1

Province	Irrigation service fee	Development cost contribution (DCC)/ amortization	Others
Maguindanao	0	0	2
Bukidnon	4	0	3

Table 38. Water charges collected by IAs

Province	Yes, they are collected	None collected, although policy says charges are to be collected	None collected, and none are assessed	No answer
Luzon				
Quezon	2	1	0	3
Cavite	0	3	0	3
Ilocos Norte	3	0	0	3
Ilocos Sur	3	1	0	4
Pampanga	4	0	0	4
Isabela	6	3	0	9
Nueva Ecija	4	3	0	7
Bulacan	1	1	0	2
Cagayan	7	2	0	9
Occidental Mindoro	1	1	0	2
Pangasinan	1	3	0	4
Tarlac	1	2	0	3
Camarines Sur	2	1	0	3
Visayas				
Bohol	13	1	0	14
Leyte	11	0	0	11
Iloilo	0	5	11	16
Capiz	0	0	5	5
Mindanao				
Davao del Sur	0	5	0	5
North Cotabato	0	4	2	6
South Cotabato	0	6	6	12
Maguindanao	0	0	0	0
Bukidnon	0	0	8	8

Table 39 was about if there are incentives for paying on time and how their rate their IA's financial strength from 0 – 4, wherein 0 being the lowest and 4 being the highest. However, as presented in Table 37, most of the IAs have incentives for paying on time. Before free irrigation, usually for type 2 models of IA not yet in IMT, there is a 10% discount if ISF is paid on time. In order to encourage the IAs to collect the ISF, NIA implements incentive schemes. Such schemes include a percentage return from the collection to be given to the IA if a certain percentage threshold of collection is met or if 100% collection is met for that season. The funds are then pooled by the IA and used for their few operating expenses such as when conducting meetings, general assembly, and honorarium for others.

Results showed that farmers think that their financial strength is just above the middle where they can at least meet the minimum requirement of running the IAs. Although many IAs think that theirs have good financial strength, the majority thinks that their financial strength is only of mediocre level. Some of the farmers in Luzon rated their financial strength below average.

Table 39. Incentive for paying on time and rating of IA's financial strength

Province	YES	NO	Rating*
Luzon			
Quezon	3	3	1.0
Cavite	3	3	2.3
Ilocos Norte	0	3	1.0
Ilocos Sur	1	4	2.5
Pampanga	1	5	3.0
Isabela	9	9	3.7
Nueva Ecija	4	12	3.0
Bulacan	0	2	3.0
Cagayan	1	9	2.0
Occidental Mindoro	0	3	3.0
Pangasinan	0	5	1.7
Tarlac	1	3	2.0
Camarines Sur	0	3	1.5
Visayas			
Bohol	10	14	3.2
Leyte	1	12	2.8
Iloilo	4	17	2.2
Capiz	4	5	2.0
Mindanao			
Davao del Sur	5	5	3.0
North Cotabato	3	6	3.0
South Cotabato	12	12	3.0
Maguindanao	2	2	3.0
Bukidnon	12	14	3.0

(*Financial rating rated from 0 – 4, with 4 being very strong)

5.2.3. Institutional and organizational

The organizational profile of the IAs was also elicited from the interview to categorize and analyze the organizational development and circumstances of the IA. According to the farmers interviewed, their IAs is run through a president wherein the leaders are chosen through election. The usual term of office for the set of officers is 2 years. Majority of the IAs do not provide compensation for the officers however, for some IAs that has compensation, it is usually in a form of honorarium per month.

Table 40 shows the IAs responses to questions pertaining to their perception towards the institution and their organization. Organizing an IA usually requires by-laws and rules in order to be registered. This is also reflected in the answers of the IA. Included in the by-laws is on how decisions were made. Majority of the IAs respond that decisions are usually made through a consensus of a quorum. Further, rules include provisions and sanctions. For instance, majority of IAs claimed that their rules have provisions on holding water users accountable in the use of their resource. There is also a provision on penalties or sanctions for violations. There are also rules which are specific to Board of Directors and/or officers to be held accountable or liable in their actions.

Other inquiries asked about conflict resolution and performance awards. Majority of the IAs have conflict resolution mechanisms. The conflict resolution ability of IA officers is critical in the development of the organization. Although many IAs claim that it is very seldom for them to engage into a formal conflict resolution mechanism, they only usually resolve petty arguments between members particularly on the topic of water distribution. Provisions in the rules that were not adequately implemented is presented in Table 41.

Table 40. Questions related to rules and conflicts

QUESTION	YES	NO	Blank	Total
Are there written rules (e.g. by laws) in the IA regarding proper behavior of farmers and employees?	130	4	17	151
Are there provisions in the rule/ ordinance holding water users accountable? (Y/N/NC/DK)	97	19	35	151
Penalty provisions/fines?	94	39	18	151
Sanctions?	13	93	45	151
If and when conflicts arise between water users, are there any conflict resolution mechanisms? (Y/N/DK)	91	37	23	151

Table 41. Provisions that are not implemented adequately

	Count
Water Stealing / Illegal Checking and Pumping	44
Monthly/Annual Dues	33
Rules and Regulations	14
None	11
ISF Payment	6
No IAMO, No Turtle Tiller	5
Inactive	5

	Count
Free Irrigation	4
No data	41
Total Number of Responses	111

On the other hand, collection delinquency is the inability of the farmers to pay their ISF. Not paying the ISF could be due to several reasons. The top reasons that were tallied based from the interviews were due to personal reasons, insufficient water, lack of funds, and damaged irrigation infrastructures (Table 42). According to the officers, many members refuse to pay since they are not satisfied with the irrigation supply. In addition, members also refuse to pay since they still believe that water and irrigation system should be a service by the government to the people, thus it should be free. Similarly, water should be free since it is a God-given gift to humanity. In some areas, political interest and statements or propaganda are the reasons why members do not want to pay. Promises made by politicians during the campaign period are used against the organization which forces them to accept things as it is. Table 43 shows the penalty imposed by IAs for delinquency in payments.

Table 42. Reason for delinquency presented by IAs

Province	Willingness to pay	Personal reasons	Poverty	Weak harvest	Delay in selling produce	Lack of water	Lack of facilities/ equipment	Canal damage	Poor engineering	Institutional	Farmers need to be oriented	Null
Luzon												
Quezon		1				2						
Cavite		2		1				1				
Ilocos Norte	2		1									
Ilocos Sur	2		2									
Pampanga	2		1				3	1			1	1
Isabela		2				2				4		1
Nueva Ecija	3	1	1	1								7
Bulacan	1		1									
Cagayan	2	1	1	1	1	1						3
Occidental Mindoro						1						2
Pangasinan	2					2						1
Tarlac	2			1		2						
Camarines Sur						3			1			
Visayas												
Bohol	3					5			4			4
Leyte	4			3		1				1	2	2
Iloilo	5			2		9						2
Capiz	2			4		1						1
Mindanao												

Province	Willingness to pay	Personal reasons	Poverty	Weak harvest	Delay in selling produce	Lack of water	Lack of facilities/ equipment	Canal damage	Poor engineering	Institutional	Farmers need to be oriented	Null
Davao del Sur			1									4
North Cotabato	2									2		4
South Cotabato	6			10								2
Maguindanao				2								
Bukidnon	5	1	1	6						1		3
Number of responses = 179												
Number of respondents = 151												

Table 43. Penalty for delinquency implemented by IAs

Province	<5% interest	>5% interest	Seize bank account	Demand letter and legal action	Cut off water supply	Others	No penalty	Null data
Luzon								
Quezon	2						1	
Cavite	3							
Ilocos Norte	2						1	
Ilocos Sur		3					1	
Pampanga	2							3
Isabela	6			3				
Nueva Ecija	2	1		2		1		7
Bulacan	1				1			
Cagayan	3	1		1	1		1	4
Occidental Mindoro							1	2
Pangasinan	4							1
Tarlac	1	1						1
Camarines Sur		1						2
Visayas								
Bohol	6				2			6
Leyte		1	2		6		1	2
Iloilo	2		2			1	2	10
Capiz	4							1
Mindanao								
Davao del Sur	1							4

Province	<5% interest	>5% interest	Seize bank account	Demand letter and legal action	Cut off water supply	Others	No penalty	Null data
North Cotabato	2							4
South Cotabato	6							6
Maguindanao				1				1
Bukidnon	5					1		8
Number of responses = 154								
Number of respondents = 151								

Finally, common issues that were experienced by the farmers were elicited. Table 44 shows the enumerated issues usually experienced by the IAs. On the other hand, Table 45 shows the suggestions to addressed IA issues and concerns. Based from the suggestions, generally, farmers will still need continuously the support of government.

Table 44. Problems/ issues encountered by the IAs and farmers

	Count
O&M of the Irrigation	54
Access to Funds for Rehabilitation (LGU, NIA, other government agencies)	49
Access to Water (Quantity and Timeliness)	41
Technical Support from NIA, Support Services from the Department of Agriculture (DA)	37
Access to Production Credit (including providers)	34
Others	12
Blank	49
Total Number of Responses	102

Table 45. Suggestion to address IA concerns

	Count
Technical Support from NIA, Support Services from the Department of Agriculture (DA)	96
Subsidy from Government	62
Government Support	40
Others	4
Blank	30
Total Number of Responses	121

5.2.4. Summary statistics of satisfaction rating and performance indexes

Different performance indicators were assessed in the study through the perception and satisfaction ratings of farmers. The basic assumption is that the higher the satisfaction rate of the farmers towards different indicators implies the effect of the IA's and the institution's overall performance for that particular indicator.

Table 46 shows the satisfaction of the IAs in terms of different performance indicator questions. On the satisfaction on IA policy on water distribution, on the average, most IAs has high satisfaction rating with an overall score of 3.30.

On the other hand, water delivery service rating shows the rate on how reliable the system in terms of delivering and managing the irrigation water. The overall average on reliability index still yielded a high score of 3.0 points. With this rating, all farms receive the required volume of water but with occasional delay.

Results of the IAs ability on conflict resolutions, effectiveness in implementing accountability provisions and ability to seek for outside help for enforcement of rules showed that they were above average. Especially with conflict resolutions, IAs seek assistance from the LGUs (barangay and city/municipal).

Table 47 shows the satisfaction of the IAs in terms of different performance indicator questions. Overall, most of the IAs gave satisfactory ratings on the different performance indicators. Table 47 shows the satisfaction rating on satisfaction on water distribution and maintenance of canals. On the average, most IAs has high satisfaction rating with an overall score of 3.20 and 3.24, respectively. This could be attributed to the systematic and coordinated maintenance practices between NIA and the IAs.

In terms of maintenance of control structures (Table 47), the overall average barely reached the "high satisfaction" mark (2.93). This could be an implication of the poor maintenance brought about by different factors such as financial, lack of equipment, etc. According to the respondents, farmers tend to prioritize the maintenance of the irrigation canal rather than the control structures.

Technical advices or assistance provided by NIA also indicates the performance of NIA and how well are these acceptable to the IAs. Results show that most IAs has high satisfaction rating. Table 47 shows that the average satisfaction rating of farmers is generally high (3.11).

Table 46. Ratings of satisfaction and performance indices of IAs

Parameter	0	1	2	3	4	Blank	Total	Average	Total
Water delivery service rating (0-4)[a]	1	3	23	70	32	22	151	3.00	129
IA policy on water distribution scheme rating (0-4)[b]	2	0	7	66	50	26	151	3.30	125
Rating of IA's ability on conflict resolution (0-4)[c]	1	0	11	55	57	27	151	3.35	124

Effectiveness of accountability provisions in a scale of 0 to 4[d]	14	2	21	48	32	34	151	2.70	117
Ability of the IA to seek for outside help for enforcement of its rules rated from 0 – 4[e]	6	9	25	39	38	34	151	2.80	117

(Note: [a]4 – all farms receive the required volume of water at the right time, 3 – all farms receive the required volume of water but with occasional delay, 2 – not all farms receive the required water more often,
1 – all farms do not receive sufficient water when needed; [b]4 – clear policy and adequately implemented, 3 – clear policy but not implemented sometimes, 2 – clear policy but not implemented oftentimes, 1 – unclear policy, 0 - no policy; [c]4 – Very effective, 3 – Moderately successful, 2 – Not very effective, 1 – Not effective at all, 0 – nothing done by IA to resolve conflict; [d]0 – not at all effective, 1 – rarely, 2 – sometimes, 3 – frequent 4 – very effective always; [e]with 4 being the most influential)

Table 47. Satisfaction ratings of IAs on NIA's performance

	0	1	2	3	4	Blank	Total	**Average**	Total
a. Distribution of water in its area	0	3	8	67	37	36	151	**3.20**	115
b. Maintenance of canals	0	1	11	63	41	35	151	**3.24**	116
c. Maintenance of control structures	3	1	24	59	27	37	151	**2.93**	114
d. Construction of facilities in the area	3	4	16	47	23	58	151	**2.89**	93
e. Collection of irrigation service fee	0	3	10	52	22	64	151	**3.07**	87
f. Collection of other fees	1	2	16	56	13	63	151	**2.89**	88
g. Technical advice to farmers	0	1	13	61	26	50	151	**3.11**	101

(Note: 4 – excellent; 3 – satisfactory; 2 – average; 1 – poor; 0 – very poor)

5.3. Assessment of Irrigation Performance using Principal Component Analysis

The study estimated the IPI using the Principal Component Analysis. Due to the difference in the nature of data collection between cycles, initial assessment resulted to a separate PCA model specific for each cycle and an integrated PCA model using common variables. Cycle 1 will include data from Luzon while Cycle 2 will include Visayas and Mindanao. The PCA results for each cycle are treated to strictly apply only for the specific group (i.e. Cycle 1 IPI will only apply for cycle 1 group). In order to compare the IPI of Cycle 1 and 2 IAs, a separate PCA model using an integrated dataset of common observable variables was also conducted. The results of each PCA model are discussed in this section.

Table 48. PCA results of Cycle 1

	Component weights			
	22.73%	**20.71%**	**19.09%**	**12.61%**
Variables	**Economic**	**Financial**	**Institutional**	**Environmental**
Annual Yield	0.5359			
Annual Gross Profit	0.6468			
Annual Net Profit	0.5365			
Annual ISF collection		0.5491		
Collection Efficiency		0.5189		
Collection Delinquency		0.6167		
Satisfaction rate on effectivity of accountability of provisions			0.7051	
Satisfaction rate on clarity of policies implemented			0.6372	
DO				0.7644
pH				0.6302

Table 49. Summary of the performance of IAs in Cycle 1.

Summary		
Low performing IAs	30	47%
Moderate performing IAs	26	41%
High performing IAs	8	12%

The results of the PCA for Cycle 1 resulted in 10 factors which contributes to the overall performance index. These 10 factors were sub classified into 4 components: Economic, Financial, Organizational, and Environmental. Based from the PCA model, 75% of the resulting performance index is explained by the model, leaving the remaining 25% as unexplained. The results also show that Economic and Financial factors are the major indicators of the IA's performance. Applying the model to all IAs resulted in a classification of Low, Moderate, High performing organizations. Note that the performance scale is based on the variables identified by the PCA, hence this specifically applies to this particular group.

Results showed that, under this rating scale, 12% of the IAs are rated as high performing, while 41% are moderate and 47% are low performing. Relative location of results for Cycle 1 is presented in Figure 57.

Figure 57. GIS map of results for Cycle 1

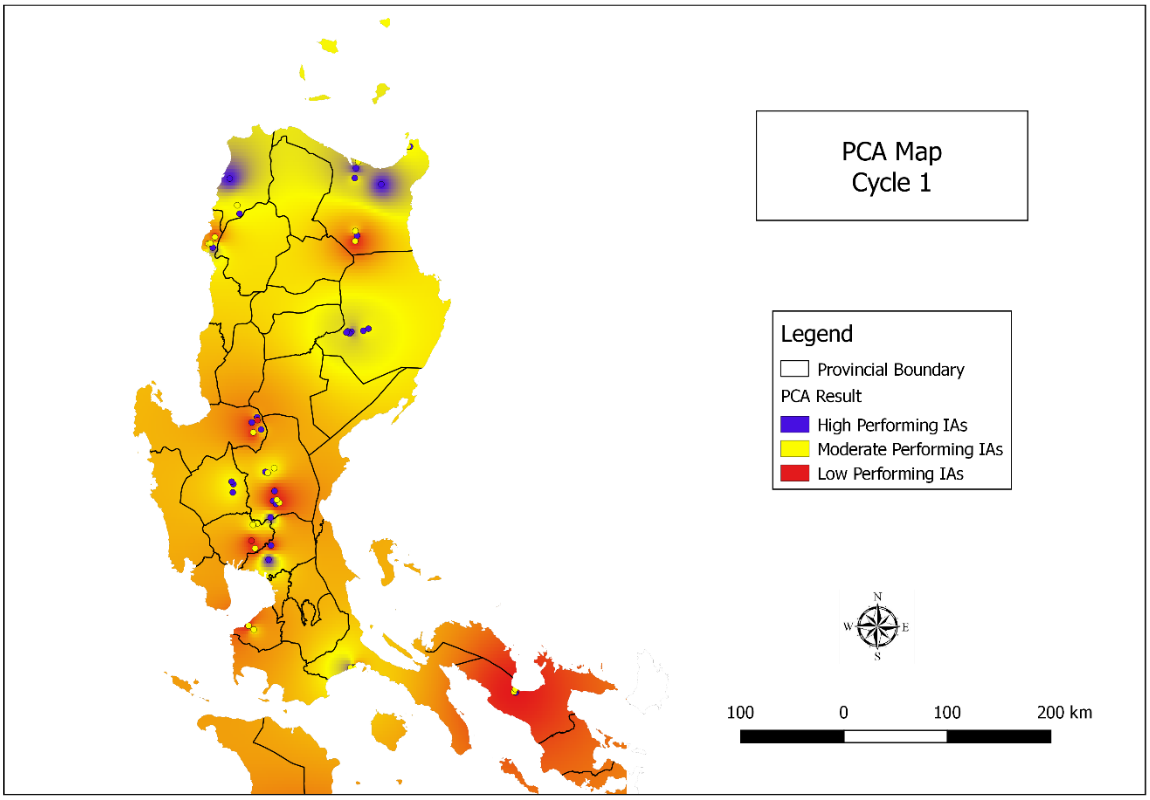


Table 50. PCA results of Cycle 2

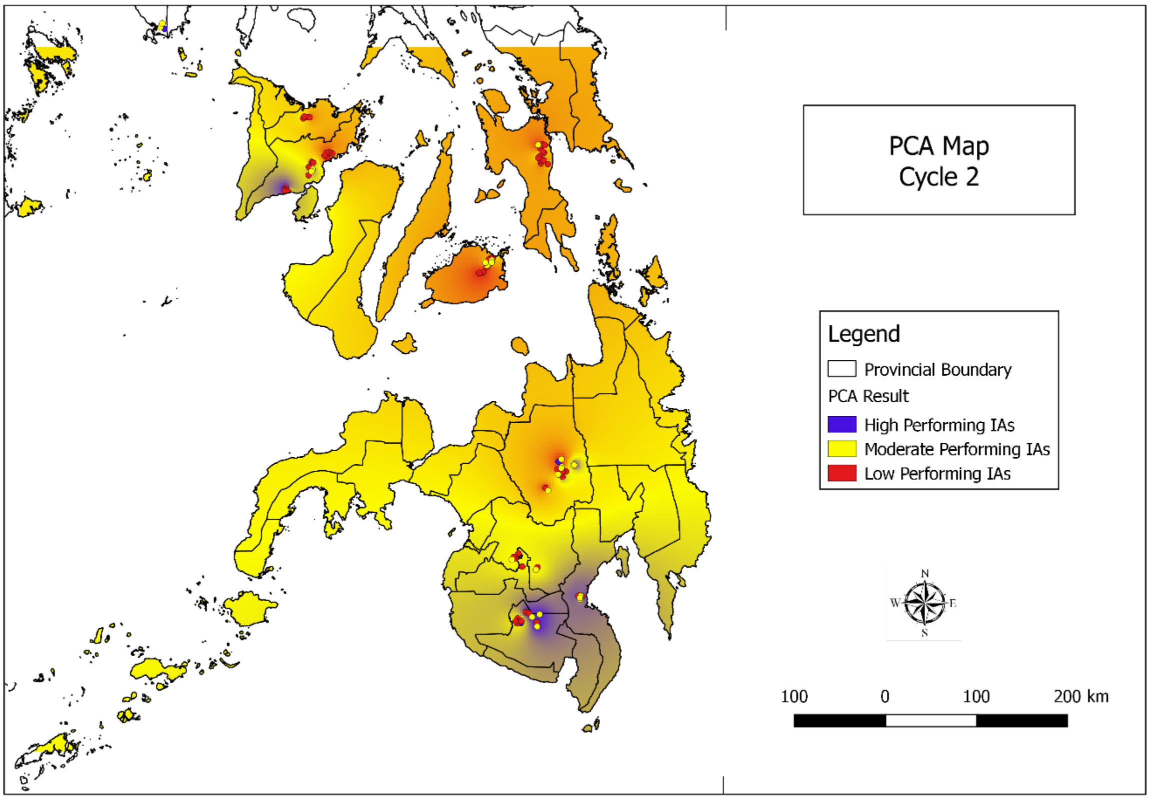
	Component weights			
	19.55%	**17.96%**	**15.39%**	**12.02%**
Variables	**Technical**	**Institutional**	**Environment**	**Economic**
Performance rate on distribution of water	0.5214			
Performance rate on maintenance of canals	0.5909			
Meeting Participation rate for GA		0.552		
Rate on conflict resolution		0.6231		
Performance rate on maintenance of control structures		0.4927		
pH (alkalinity)			0.578	
Electric Conductivity (salinity)			0.5941	
Rate of IA's financial strength				0.6243
Rate on technical advices to farmers				0.5725

Table 51. Summary of the performance of IAs in Cycle 2

Summary		
Low performing IAs	28	32%
Moderate performing IAs	39	45%
High performing IAs	20	23%

In Cycle 2, the level of performance for the 87 IAs is broken down as follows: 28/87 (32%), 39/87 (45%), and 20/87 (23%) are showing Low, Moderate, and High performance, respectively. Again, the low performing IAs are mostly located in the downstream part of the main canal. This confirms that water distribution and availability is a major factor that affects irrigation performance on the IA level. This finding towards the location of IAs is also consistent on the correlation sign estimated from the regression model of their Irrigation Performance Index (IPI). Relative location of results for Cycle 2 is presented in Figure 58.

Figure 58. GIS map of results for Cycle 2



Since the determinants of "localized" PCA model for Cycle 1 and Cycle 2 were different, PCA results for both Cycle 1 and Cycle 2 only applies within their respective groups. However, anecdotal evidences from interviews claim that free ISF has improved the satisfaction of IAs (not to be confused with the "Performance Index") despite some complains from few IAs (especially in Jalaur RIS) which claims that free ISF has reduced their funds allocated for maintenance of canals related to siltation. However, in the development of Irrigation Performance Index (IPI), a mutually exclusive PCA model integrating common observable data from Cycles 1 and 2 with a total sample size of 151 IAs throughout the Philippines, results show that only 23% of the samples have high level of irrigation performance while those having moderate to low performance are 33 and 45%, respectively.

Integrated Analysis for Cycle 1 and 2

Using the IPI from the integrated analysis allow for the comparability between groups. The mean IPI of Cycle 1 showed higher score than Cycle 2, hence this imply that the performance of IAs in Cycle 1 seem to perform better than IAs in Cycle 2. Most of the low performing IAs are from Visayas and Mindanao. It should be noted in the integrated analysis, a dummy variable representing ISF (i.e. whether IAs are collecting ISF or not) was used and results imply that ISF is a significant factor that is likely to increase IAs performance.

The resulting PCA model excluded "annual yield", "stream location", and "ISF" data to integrate both Cycles 1 and 2. Eventually, the PCA model computed 10 specific factors as main indicators for the IAs' performance index (Table 50). These factors were classified into 4 components: Economic, Technical, Environmental, and Institutional. Figure 59 shows the distribution of effect between components as performance indicator. The results show that Economic and Technical components are the prime indicators for the IAs performance index.

Figure 59. Distribution of the effects of Component weights for Integrated Analysis of Cycles 1 and 2.

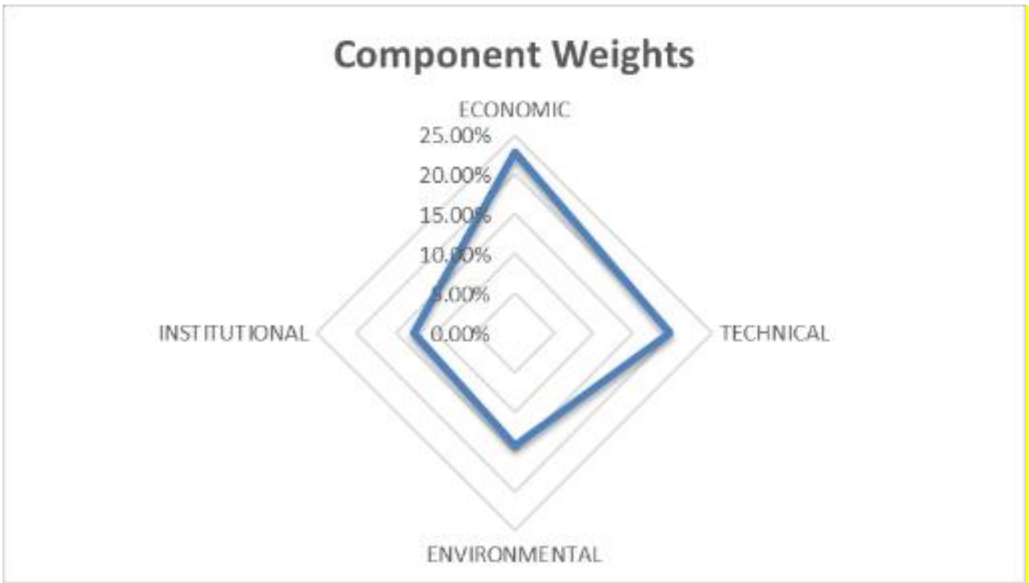


Table 52. PCA results of Cycles 1 and 2.

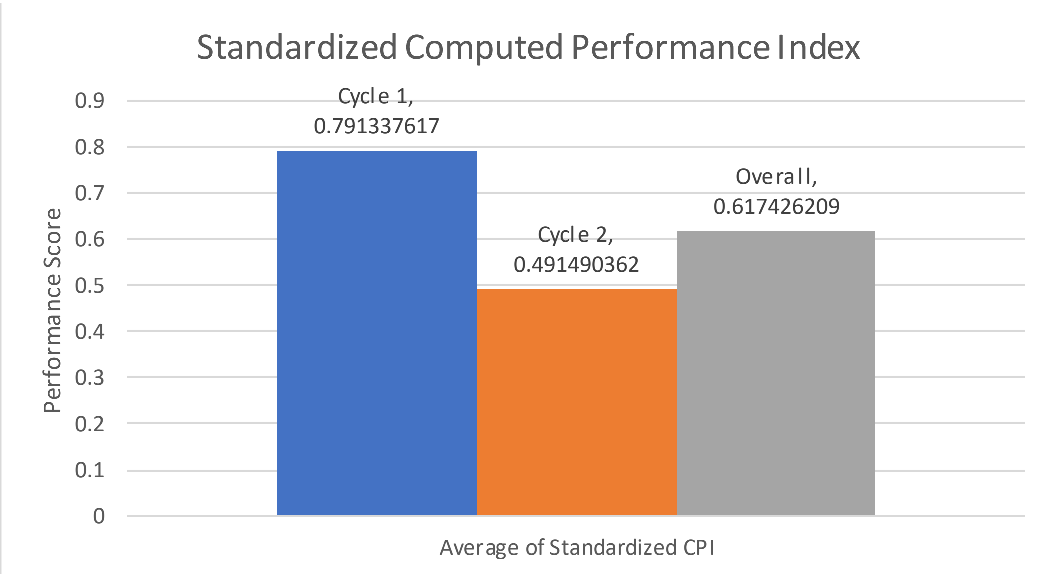
	Component weights			
	22.90%	**19.67%**	**14.18%**	**12.75%**
Variables	**Economic**	**Technical**	**Environmental**	**Institutional**
Number of Cropping per year	0.4938			
Annual Gross Profit	0.6094			
Annual Net Profit	0.5966			
Performance rate on distribution of water		0.5776		
Performance rate on maintenance of canals		0.6324		
Rate on technical advices to farmers		0.5117		

	Component weights			
	22.90%	**19.67%**	**14.18%**	**12.75%**
Variables	**Economic**	**Technical**	**Environmental**	**Institutional**
Dissolved Oxygen			0.6969	
pH (Acidity)			0.7086	
Ability to seek for outside help				0.749
Meeting Participation rate for BOD				0.6397

Based from the PCA computation, the indicators explain at least 70% of the performance index. Given the rating scale and the set of indicators, results show that majority of the IAs are in the moderate and high performing category. However, in between Cycle 1 and Cycle 2 groups, Cycle 1 are generally classified in Moderate and High performing IAs.

To validate this, we consider using the mean performance score as benchmark to compare between IAs from Cycles 1 and 2, and results showed that the mean score of IAs from cycle 1 are above average whereas the mean score of IAs from Cycle 2 is below the mean performance index, as shown in the Figure 60.

Figure 60. Standardized Computed Performance Index



A t-test statistic was also conducted to investigate whether the mean difference between the two groups are indeed valid. This affirms that the Cycle 1 performance is significantly different from Cycle 2 group hence validating the claim that Cycle 1 group's mean performance rating is indeed higher than Cycle 2 group.

To further determine the effect of ISF in the IAs performance, a regression model was conducted in the IPI from the integrated analysis between Cycle 1 and 2. The model estimated that the presence of ISF highly likely to affect the performance index of the IAs by a score of 0.30. Intuitively, this suggest that the presence of ISF increases their performance index in terms of efficient usage of their resource. Since there is cost implication from the ISF, IAs tend to manage the use of their resource more efficiently.

This is also evident in the PCA model indicated by the Technical component. The results of the regression are shown in the Table 53.

Table 53. Results of Regression Analysis for Integrated Analysis of Cycles 1 and 2.

Variable	Coefficient	Std. Error	P-Value
Loc_down	-0.0189746	0.0301518	0.530
Loc_mid	-0.0086407	0.0323526	0.790
Loc_up	0.0299249	0.0294059	0.311
Annual yield	0.000683	0.0002657	0.011**
Presence of ISF (w/ or without ISF)	0.3033828	0.0253181	0.000***
_constant	0.3516904	0.0574767	0.000***

*** significant at 1%; ** significant at 5%

The regression result showed that the dummy variables for the location of the IAs are not likely to have an effect towards their performance index. This is likely probable particularly if the IAs have efficient management of the irrigation structures as reflected in the separate PCA results for Cycle 1 and Cycle 2. However, although the p-value did not result to a significant effect to the index, notice that as the location goes downstream, the relationship towards the performance index decreases.

On the other hand, the “annual yield” and “presence of ISF” displayed high statistical significance to affect the IAs performance index. Since “annual yield” is a common indicator, it is just expected that higher annual yield also indicates better performance. In this case, an increase in annual yield by 1 unit increases the index by 0.0007 score point. However, a more interesting result is in terms of the presence of ISF or Irrigation Service Fee.

Instead of using the actual amount of ISF collected, the study used a dummy variable to indicate whether the IAs are collecting ISF or not. This is because there is data variation from ISF collections from Cycle 1 but none from Cycle 2 since they all pay 0 amount. Hence, this skews the analysis of the variable. Using a dummy variable instead makes both Cycle 1 and Cycle 2 comparable, hence yielding a better estimate.

Figure 61. Performance Index vs Yield

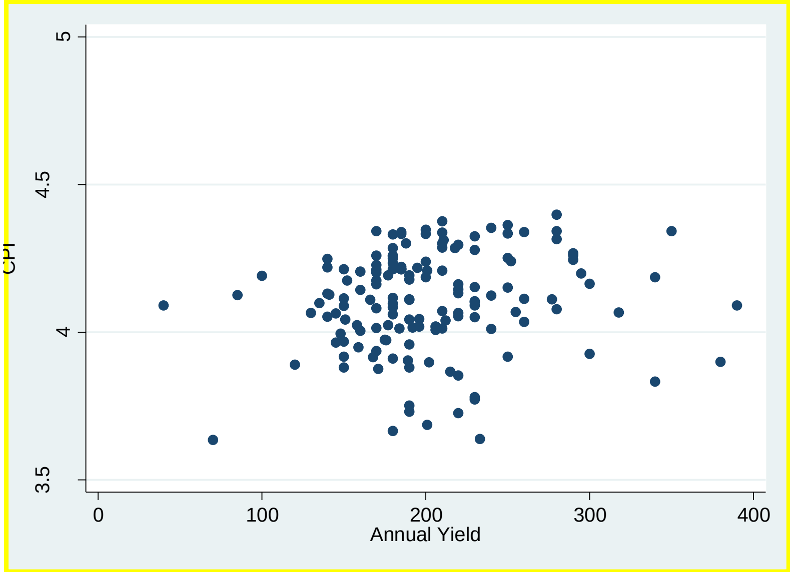
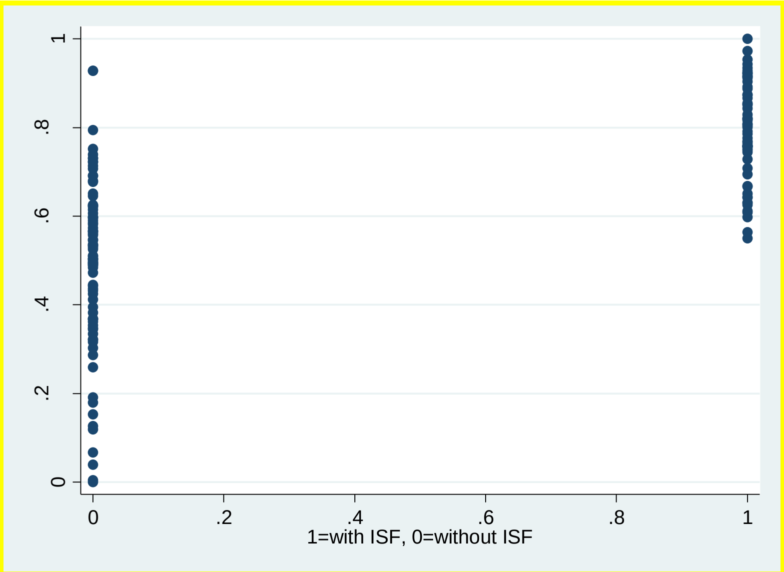


Figure 62. Result of regression with the presence of ISF



The results showed that the presence of ISF is highly significant to likely affect the performance index of the IAs. Furthermore, the model result indicates that IAs with ISF is highly likely to increase the performance by 0.30 score point. This is particularly substantial in terms of increasing their performance. Intuitively, this also follows theories pertaining to resource maximization since the presence of ISF shows a resource constraint which needs to be maximized. The presence of this resource constraint represents opportunity cost for farmers hence, they need to make the most out of the resource since it is scarce and has cost implication.

Table 52 shows the list of IAs with low, moderate and high performance. Out of 151 IAs, 68 are low performing where majority comes from Visayas and Mindanao. Relative location of results for Cycles 1 and 2 is presented in Figure 63.

Figure 63. GIS map of results for Cycles 1 and 2.

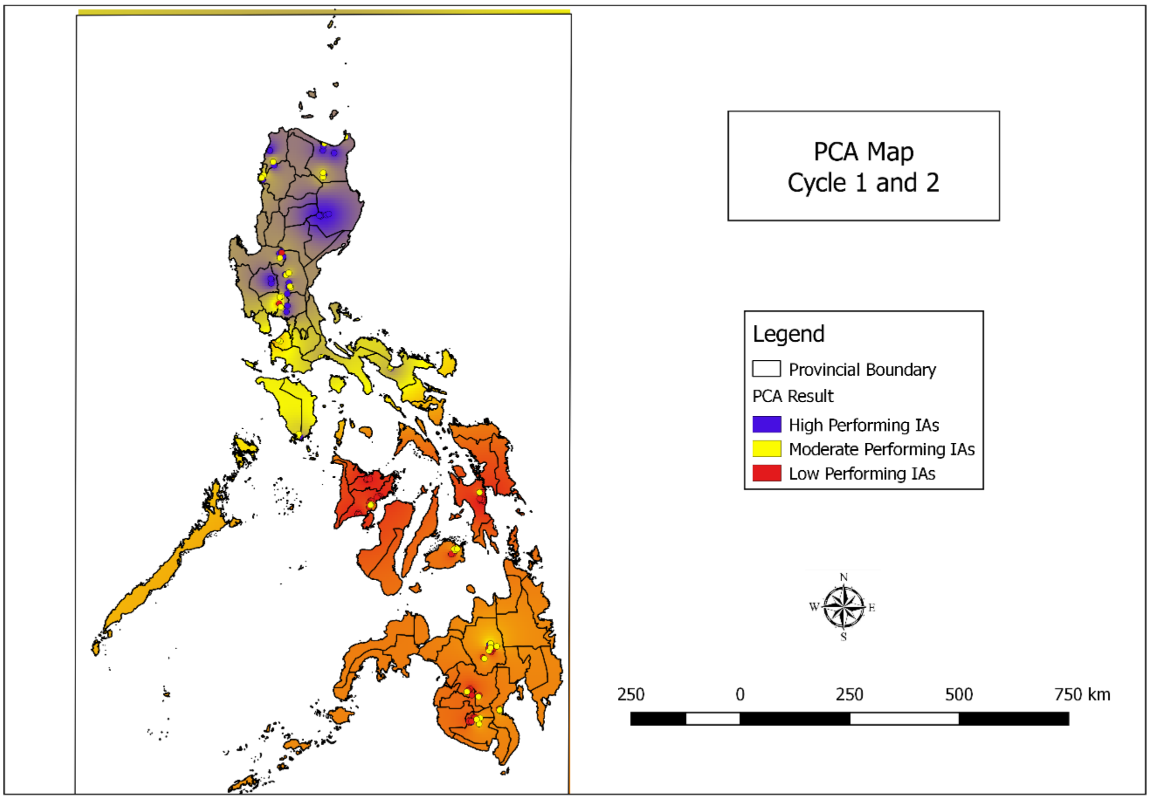


Table 54. List of Low, Moderate, and High Performing IAs.

Low	Moderate	High
Bohol	*Bohol*	*Bukidnon*
BODCASACAL IA	AAIA2	Bukidnon IA
Oryza Sativa Linn	CAM-BA-SAN Irrigators Association Inc.	*Bulacan*
San Babue	GABIBU	Bagbaguin-Manatal
San D Mil	GBL-IA (Gabi Bulilis Lomangog)	Masacp-Pisacamba IA
Triple C&T	MBK Good farmers Irrigators Association, INC	*Cagayan*
Tubocalin IA	*Bukidnon*	Camalap IA
Bukidnon	Bangcud, Cabangahan, Aglayon IA	Dagupan IA Section 3 Cabisia
(MASBA) Mailag San Carlos Bagontaas IA	Colonia IA	Lal-lo IS
ARFI Araneta Lugong IA	Hindangon Hagkol Poblacion	Northern Solana Rice Producer IA
Batangan Malabuaya Inawaan IA	Mailag Colonia IA	*Camarines Sur*

Low	Moderate	High
Kahaponan Valencia City IA Inc	Patag-Corona IA	Labao Boguites IS
Salvacion Maramag IA	San Martin North Main Canal IA Inc	*Ilocos Norte*
Sinayawan Lateral G6 IA Inc	*Cagayan*	Before: Laoag-San Nicolas IA; Now:San Nicolas Damilyan IA- Bonga Pump 2
Vintar Valencia City IA	Kavisya IA	Kadaklan Baldias IA
Capiz	Muhara	*Ilocos Sur*
GUINTTU	NWSFIA	Paing-Taguipuro IA
PAMMANBBA	Zigiran-Dodan IA	*Isabela*
PAMPBU	*Camarines Sur*	Bagong Silang IA
PASIMROBA	Bigong Patag Cagampis IA (BPCIA) & Pandan New Poblacion Camagong IA (PNPC IA)	Der-an IA
TATAG	Candatu-Labao-Patag-Tarcum FIA	Golden Hope IA
Cavite	*Cavite*	Lateral D1 & B Salinongan IA
Balite Munti Irrigator's Association Inc.	Bucal-Pasong Malainan Luma IA	Mabisa IA
Davao del Sur	Malaking Pilapil/Magabe C IA	New Life IA
BASIS FIA	*Davao del Sur*	Victory IA
Bayanihan Hagonoy Zone 3	LAPOSA IA	
Sacub IA	UPSFIA-Upper Sinayawan Farmer IA	*Nueva Ecija*
Iloilo	*Ilocos Norte*	Biyaya-Radar IA
Banuba IA Tigbauan	Caniyogan-Balbalay-Kau Alakay IA	Flume IA
Bariga Magdalo Farmers IA	*Ilocos Sur*	LRTRIS FIA
BOTAPAC IA	Kabukiran	Mapamasa IA
CASANDEL IA	Macagui	Penaranda IA, Inc.
Cordova IA Inc	VSPC / San Hera de Magsinggal / Western Mags 2 / Pansaca	*Occidental Mindoro*
Dita IA	*Iloilo*	Gamot Bolo Nicolas IA
Hampad Pampang Proper IA Inc	TUMCAN Irrigators Association Inc	*Pangasinan*
Lateral B-Tigbauan IA Inc	TUPOBA Farmers IA Inc	Kaps Ambayoan
LIBU IA	*Leyte*	Main Canal Ambayoan Saranay IA
Merced Carmelo IA	Bakaslipi IA	SMD-Samahang Magsasaka ng Gonzalo
Nabiba tigbauan Inc	*North Cotabato*	*Quezon*

Low	Moderate	High
SALMIG	MLARIS Division A. (BIMADU) IA Inc.	Mayao Castillo Lucena IA
Sambaloca IA	SARAPANI Irrigator Association Inc	*South Cotabato*
SANSIMDA IA	*Nueva Ecija*	Highway Katilingban IA
VANI IA Inc	Bagumbos	*Tarlac*
Leyte	Gamaca IA	Dalayap Tarlac FIA
Binouigay Farmers-Irrigators Service Coop.	Kapit Bisig IA	Himala IA
CAGUICA	Laham IA	Maliwalo IA at Lateral A
CAMACA	Makabilog-Maynabo-Tambo IA	
Cutay, Canmamotong, Victoria, Alaklihaw IA	Maranac IA	
Guinarona	(blank)	
KAHAYAG-LIBAG IA Inc.	*Occidental Mindoro*	
Kasaganahan IA	Bugtong Buni Olima IA	
Lanauan TIN-AO, Balilit San Isidro IA	Purnaga Magsaysay IA	
MAGKAUROSA IA INC.	*Pampanga*	
San Roque Hetala IA	Kansinala IA	
Sidlit farmers Irrigator Service Cooperative	Magcasaup IA	
Maguindanao	Mazario Binuya IA	
Gagdanen Baya IA, Division 1 Inc.	Sto. Nino Candating	
Morning Light IA	*Pangasinan*	
North Cotabato	Carsan Kudung Dungo IA	
BAGONABATI IA Inc	*Quezon*	
BALATIKAN IA	Ginintuang Butil	
Dalingaoen Farmers Irrigators Association of Pikit	Nagkakaisang Magsasaka ng Bantigue IA	
MLARIS Division B. (LIDANAMA) IA Inc.	*South Cotabato*	
Pampanga	CALOMOR Irrigation Association Inc	
San Carlos-Sta. Rita-San Pedro IA, Inc.	Lenticels IA	
Pangasinan	Morning Star IA	
Salud-San Eugenio		
South Cotabato		
CABUMADU IA		
Country Folks IA		
DAWN IA		

Low	Moderate	High
Midstream IA		
Paghidaet-Malipayon Center Irrigators Association Inc		
Rice Field IA		
Roxas Macapagal Lambunao IA (ROMALIA)		
Sta. Cruz Magsaysay Maupayon (SCMM)		

6. Conclusions and Recommendations

6.1. NIS Project Summary

This Project is envisioned to characterize and evaluate the Technical and Institutional dimensions of NIS. With water quality not a priority program of NIA in its previous and on-going development projects, and thus no water quality information is available in all NIS managed or transferred by NIA, it was decided to include an environmental aspect in the performance assessment of NIS cases covered. As such, in addition to the 3 basic indicators considered such as CI, ISF and ratio of irrigated over service area, additional indicators related to physical and environmental aspects of irrigation performance were included.

In this Project, 39 representative NIS cases in Luzon, Visayas and Mindanao are selected based on some criteria such as location, size, performance (successful/non successful), and irrigation technology (gravity vs pump) which are either managed by NIA or transferred to IAs under the IMT programs of NIA which empowers IAs to operate and manage irrigations systems in four schemes (i.e. model 1 to model 4). Also, the effect of Free irrigation was considered during the FGDs and KIIs in Visayas and Mindanao.

The evaluation approach adopted in this project consists of walkthroughs/field visits/interviews, measurement of water flow and quality from selected stations in the main and lateral canals and questionnaire surveys, KII and FGDs for IAs representing the upstream, midstream and downstream part of the main canal or laterals which are based on the RAP approach under the MASSCOTE framework.

GIS was also applied to map location of surveys, structures and measurements as well as to perform spatial analysis of erosion, groundwater potential, coastal flooding and performance levels of the NIS cases at the IA level.

Another innovative approach adopted in this project is the application of PCA to assess the performance of the NIS cases considered at the IA level using four major categories of indicators such as Technical/Physical, Institutional/Organizational, Economic and Environmental. Within these major indicators are numerous factors which are analyzed using a correlation matrix to determine its loading factor or weight which is then used to derive the performance index of the 151 IAs considered. Based on this composite index which is a function of the relative weights of the factors analyzed, irrigation performance is described into three levels such as poor, moderate and high. Then the performance levels of the 151 IAs evaluated was presented using GIS maps to demonstrate the distribution of IA performance in the 39 NIS cases covered.

Many technical and environmental issues confront the NIS covered based on the ocular inspection, walkthroughs and measurements of water flows, quality and siltation. In our face to face discussion with the Engineers and Field guides, some pressing issues raised consist of 1) non-functional, missing or damaged structures (check gates, staff gauges, etc.); 2) siltation and lack of canal maintenance; and 3) lack of policy or its weak enforcement with regards to canal maintenance, illegal settlers, illegal pumping and dumping of garbage. In addition, animals (especially carabaos) are frequenting the earth canals which cause damage and collapse of the canal side slopes which can result in more serious problem such as reduction in capacity and increase in maintenance costs. In some cases, there are misplaced or damaged structures (concrete turnouts or division boxes) which need immediate restoration to maintain its designated functions

Results of the evaluation from measurement, interviews and performance assessment are presented in terms of the major issues/concerns among NIS cases related to Physical, Institutional and Environmental aspects of irrigation management as well the performance levels of the 151 IAs considered in the analysis.

The major issues under Technical/Physical include siltation problems in canals of almost all NIS cases causing reduced flow capacities that deprive the downstream portion from adequate water supply. The reason is lack of maintenance especially. of unlined canals and poor watershed management which results in upland erosion and siltation of the rivers and canals downstream of the watershed. In addition, staff gauges are lacking or missing in most NIS cases visited which limits information on available flows; and canals/structures are damaged which affect water delivery service. In effect, the delivery performance ratio, an indicator which describes the actual over design discharge cannot be assessed yet but needs to be determined to show the water delivery efficiency of the systems. Flooding problems also exist in most NIS especially during wet season which limit cropping to dry season only and thus reduce Cropping Intensity. Also, drainage canals are lower than the river so flooding problems exist especially during wet season since drainage canals cannot drain out the excess water.

Tables 55 and 56 present a summary of the IAs responses to technical and irrigation operation inquiries. From Tables 55 and 56, it is evident that most of the respondents have indicated silt problems in canals and difficulty in operating check gates/structures in the system are the major technical concerns in NIS.

Table 55 is a summary of KII for technical issues across all NIS in the Philippines in terms of canal conditions (e.g. siltation) maintenance and operation of structures as well as satisfaction rating based on Flexibility, Reliability, and Equitability Indices. It can be seen that most NIS in the Philippines are facing siltation problems in canals (i.e bet 50 to 75% are affected). Ease of operation of structures such as cross regulators and offtakes on the other hand have average rating across the NIS in the Philippines, while satisfaction rating based on the 3 indices of Flexibility, Reliability, and Equitability indicate that they have above average rating of ¾ across all NIS in the Philippines.

Table 56 is a summary of the KII for technical issues across all NIS in the Philippines in terms of structures and systems operation and management. It appears that the rules and policies for operations of structures (e.g. cross regulators, offtakes etc) are strictly followed with some minor deviations in some NIS across the Philippines. Also, in terms of water management, most NIS in the Philippines are practicing AWD and drainage re use which indicates the farmers awareness on current technology for water saving especially during times when there is water shortage.

Table 55. IA responses to technical inquiries

Questions	LUZON		VISAYAS		MINDANAO		PHILIPPINES	
	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL
Silt in canals (4=high, 0=low)	2.53	57	2.29	7	1.44	8	2.38	72
Percentage of a typical canal section that is filled with silt, (0= 0%, 1<=25%, 2<=50%, 3<=75%, 4<=100%)	2.23	35	1.43	7	1.29	7	1.98	49
General lack of undesired seepage (0-high seepage, 4-very little seepage)	2.67	52	2.71	7	3.36	7	2.75	66
Availability of staff to adequately maintain the assigned canal sections (0-not adequate, 4-adequate)	3.31	54	2.07	7	2.38	8	3.08	69
Availability of proper equipment to adequately maintain the assigned canal sections (0-not adequate, 4-adequate)	2.24	55	1.43	7	0.94	8	2.01	70
General condition of cross regulators	2.02	51	3.07	7	2.88	8	2.23	66

Questions	LUZON		VISAYAS		MINDANAO		PHILIPPINES	
	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL
(0-Worst, 4-Excellent):								
Ease of cross regulator operation (0-impossible to operate, 4-very easy to operate):	2.50	42	3.29	7	3.00	8	2.67	57
Availability of roads along the canal (0- no access, 4-very good access):	2.88	49	2.86	7	3.06	8	2.90	64
Can they operate as needed? (4-very easy, 0-difficult to operate):	2.83	52	2.93	7	3.00	7	2.86	66
Are they physically operated as designed? (4-excellent, 0-not operated as designed):	3.12	50	2.86	7	2.83	6	3.06	63
Personnel from what level operate the offtakes? (1=this level, 2=lower, 3=both):	1.93	44	3.00	7	2.50	8	2.14	59
Flexibility Index (0-schedule unknown, 4-highly flexible)	3.06	49	3.21	7	2.88	8	3.05	64
Reliability Index (0-unreliable, 4-available as scheduled)	3.21	52	3.57	7	3.81	8	3.32	67
Equitability Index (4-100% of the area has equitable distribution, 0-	3.53	47	3.57	7	3.44	8	3.52	62

Questions	LUZON		VISAYAS		MINDANAO		PHILIPPINES	
	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL	AVE	TOTAL
no consistent pattern)								

Table 56. Summary of responses pertaining to irrigation operation

Questions	LUZON				VISAYAS				MINDANAO				PHILIPPINES			
	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL
Is there an existing system of operation for the canal cross regulator/s ?	44	8	8	60	7	0	1	8	6	2	0	8	57	10	9	76
Are operators allowed to have deviations from the approved system?	8	39	13	60	5	2	1	8	2	4	2	8	15	45	16	76
Is there a time the operation made deviations?	12	33	15	60	3	2	3	8	3	1	4	8	18	36	22	76
Is there a line of communication between the operator and IA?	51	2	7	60	7	0	1	8	8	0	0	8	66	2	8	76
Is there an existing system of operation for the offtakes?	40	4	16	60	7	0	1	8	7	1	0	8	54	5	17	76

Questions	LUZON				VISAYAS				MINDANAO				PHILIPPINES			
	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL	YES	NO	Blank	TOTAL
Are operators allowed to have deviations from the approved system?	7	34	19	60	4	2	2	8	4	2	2	8	15	38	23	76
Is there a time the operator made deviations?	18	23	19	60	6	0	2	8	3	1	4	8	27	24	25	76
Are there any direct farm offtake (<2has) from the Main/Lateral Canal?	25	15	20	60				0				0	25	15	20	60
Do these direct farm offtakes affect operation?	16	5	39	60				0				0	16	5	39	60
Are there farmers practicing alternate wet and dry method?	31	22	7	60	5	2	1	8	5	2	1	8	41	26	9	76
Re-using drainage water for irrigation?	19	16	25	60	6	1	1	8	8	0	0	8	33	17	26	76

The issue on siltation is further validated by the degree of lining of main canals and laterals in selected NIS cases. The efficiency of water distribution is a function of the condition of the main canals and laterals especially in terms of the lining coverage and degree of siltation. It was emphasized earlier that siltation causes reduction in discharge capacity of canals and results to poor water delivery esp. in the downstream part. In view of the perennial problem of poor water distribution in NIS cases due to lack of maintenance and siltation of main canals and laterals, it is being contemplated to adopt pipe irrigation system in NIS. To evaluate the feasibility of this option, Table 57 shows the comparison between lined/unlined canals and pipelines.

Table 57. Comparison between Earth/Lined Canals and Pipelines as main and secondary distribution waterways

Features		Lined/Unlined			Pipeline	
Design		Trapezoidal, earth or concrete			Circular, Steel or Iror	
Dimensions		Z, D, W, T			Diameter	
Maintenance		Cleaning/ Disiltation			Flushing	
Efficiency		40-70%			80-90%	
Life span		short term			Long term	
Pros/Cons		Low initial cost, high maintenance			High initial cost, low	
		high water losses			water losses nil	
Recom		make a cost benefit analyis to establish/justify pipe use				

(Source: Taken from Irrigation Books and Lecture Notes)

Based on Table 57, it is worth exploring on investing for pipe network since the cost of maintenance is low, and conveyance/distribution efficiency is high as seepage and percolation losses are minimal. Also, evaporation loss especially during summer is basically nil since it's an enclosed system. But the return to investment can be obtained after several years of operation. A detailed cost analysis is needed to estimate the investment needed and when the cost will be recovered. A pilot project is recommended to establish its feasibility and viability with respect to economic, technical and social implications.

For now, the use of pipes in the mains and laterals will not be economically feasible. As discussed in the Final Report, repair or rehabilitation of main and lateral will disrupt operation for at least two cropping seasons. In all the NIS covered, problems raised include siltation and solid waste clogging. This will be a major problem in a pipe system even if it has a control system for silt and clogs.

It is recommended to use pipe system in main and lateral canals on a case to case basis, in cases where there are:

a. Sections prone to erosion;
b. Sections damaged by high flows;
c. Sections silted by nearby hill or sloping areas;
d. Sections for road widening (partial only);
e. Sections to be used for multi-purpose like drying pavement, community space/park, etc but not for residential and commercial purposes

It is recommended to implement pipe system in small laterals and farm ditches (main and supplementary). Pipe system will support land consolidation. This is to facilitate farm operations, especially mechanization activities.

On the Institutional aspect, the KII and FGDs of the different IAs representing the 151 NIS, have generated some findings which have come out as the important issues related to the Institutional/Technical performance of selected NIS cases. Lack of policy or its weak implementation on illegal settlers, dumping of garbage, and illegal pumping has caused both delivery and environmental issues. Other issues include poor water delivery scheduling and distribution and conflicts among users especially when upstream members block the path of water which reduces the water supply for the downstream part. Farmers are also resistant to change and new technology adoption and some are hesitant to pay ISF because of poor water service especially in the downstream part. Many farmers are still traditional and don't follow crop calendar. Another pressing issue is the high prevailing costs of inputs while selling price of harvest is low. Informal settlers along the canals pose solid waste problems. Farm to market roads are also in poor condition in some IAs and they are not passable especially during wet season.

On the environmental aspect focusing on water quality, most NIS cases showed pH levels on the alkaline side (> 7) which can be attributed to excess sodium and can therefore lead to sodicity problem in the future and pose serious problem on water quality especially if this is combined with high salinity levels. In fact, some NIS cases (especially those pumping ground water like TGIS) and due to sea water intrusion (e.g. Magapit PIS), salinity is a problem (i.e. EC is > 300uS/cm) which can pose serious effects on crop development and yield if not properly addressed. Another important water quality indicator which affects photosynthesis and thus biomass production is DO which was found to be low (i.e. 6 < ppm) in some NIS case (e.g. downstream of Vaca dam and PDRIS end of downstream. This can be attributed to the thick aquatic vegetation just upstream of the Vaca dam which has caused the reduction of DO downstream. DO is very important in photosynthesis which is responsible for biomass production. The effect of poor water quality, especially on crop productivity has not been established yet since data on yield of the different NIS cases visited are not yet available. During the site visits, transplanting has just started so it would be important to gather information on yield, so we can assess the effect of poor water quality on crop productivity (i.e. yield per irrigated area). We expect this information to be available during the next cycle and thus can make more analysis on the relationship between water quality and yield.

6.2. Conclusions

Many technical/institutional/environmental issues confront the NIS covered based on the ocular inspection, walkthroughs and measurements of water flows and quality and siltation. In our face to face discussion with the Engineers and Field guides, some pressing issues raised consist of 1) Non-functional, missing or damaged structures (check gates, staff gauges, etc.) Siltation and lack of canal maintenance, and 3) Lack of policy or its weak enforcement with regards to canal maintenance, illegal settlers, illegal pumping and dumping of garbage. In addition, animals (esp. carabaos) are frequenting the earth canals which cause damage and collapse of the canal side slopes which can result in more serious problem such as reduction in capacity and increase in maintenance costs. In some cases, there are misplaced or damaged structures (concrete turnouts or division boxes) which need immediate restoration to maintain its designated functions.

The technical aspects included in the analysis consists of the effect of lining on water distribution efficiency which in turn affects water delivery service as most downstream users complain of inadequate water in their areas. Most unlined canals are also silted which reduces the discharge capacity of the distribution systems. Water losses and low capacity are the main technical reasons for poor water service delivery. That is why a comparison between unlined/lined canals and pipe network was presented in Table 57 to explore the potential of pipe use because of its high efficiency (low conveyance losses due to seepage and percolation) and low maintenance costs. This will be part of the recommendations.

The above key issues identified during the site visits need to be addressed to improve performance of the NIS cases considered. As to the deliverables or expectations from the NIS component, the following conclusions are drawn as per objectives of the project as follows:

Objective 1: Characterize the distribution of all the NIS; examine the trends and patterns of performance indicators of NIS across the different systems in the country, based on primary and secondary sources.

The distribution of NIS performance across all systems in the Philippines, is clearly explained by the results of PCA which indicates which IAs in every NIS have shown low, moderate and high performance. The analysis was done using both secondary data (from NISPER/CO) and primary data (from IAs questionnaire survey and field visits and water flow and quality measurements). The distribution of IAs performance is reflected in the GIS maps for the whole country and results show that almost all IAs in Visayas and Mindanao are showing low level of performance based on the combined effects of Technical/Institutional, SocioEconomic and Environmental factors.

In reference to the trends and patterns of performance, indicators such as Irrigation intensity (II), Cropping Intensity (CI), ratio of irrigated area to service area, ISF collection and viability index, were used to assess the different NIS in the country. Except for Manupali RIS, most of the target NIS in Mindanao has relatively higher Irrigation Intensities. Irrigation Intensity is generally increasing in Jalaur-Suage RIS, Mlang RIS with a slight dip in 2014 and 2015, Marbel RIS, Banga RIS with a slight dip in 2013-2015, and Padada RIS, was fluctuating in Mambusao RIS, Sibalom-Tigbauan RIS, Capayas IS and Bayongan IS. The average irrigation intensity (2013-2017) for the target NIS in Bohol ranges from 96% to 144%.

For the Cropping Intensity, the average CI (2010-2014) for MARIIS ranges from 184% to 226%. The high cropping intensity was due to third cropping and QTA in some sections of the irrigated area. The average CI for the Ambayoan-Diplao RIS, on the other hand was quite low ranging from 86 to 109% (2010-2014). The reason is that structures were destroyed during 2014 typhoon and there are canals that have become shallow due to siltation. In the Dumacaa RIS, average CI ranges from 142% to 168% (2010-2014). Other than problems with canal lining, another reason for the relatively low cropping intensity was the declining water intake. Actual irrigated area was lower than FUSA even in the existence of intake and reuse dams within the service area. The average CI for Bukidnon NIS ranges from 81% to 186% (2013-2017). The main reason reason for the relatively low cropping intensity were siltation and low water supply. On the other hand, the average CI for South Cotabato NIS ranges from 178% to 186% (2013-2017). The relatively higher cropping intensity may be attributed to high percentage of lined canals and the synchronized scheduling of irrigation.

Some NIS have a few IAs but they have low cropping intensity while some have many IAs but high cropping intensity. M'lang and Roxas-Kuya RIS have only 2 IAs each but have lower cropping intensity compared to Marbel #1 with 18 IAs. The more IAs present in a system, the more farm areas share the irrigation water. This phenomenon could be explained by the presence of re-use and supplementary dams in Marbel #1 where even many IAs are sharing the irrigation water, there is ample supply to allow more areas to be planted and irrigated, thus higher cropping intensity.

In terms of ISF in relation to performance, this is not included as a factor in Visayas and Mindanao since Free irrigation was introduced in 2017. IAs in Visayas and Mindanao seem to be happy with free ISF despite some complains from few IAs (especially in Jalaur RIS) that free ISF has reduced their funds allocated for maintenance of canals related to siltation. However, in the integrated analysis of Cycles 1 and 2, IAs in Cycle 1 appeared to have performed better. A more detailed comparison of the two Cycles are indicated in the conclusion part of the Performance assessment using PCA

Based on the above, it can be concluded that the NIS have varying patterns and trends of performance indicators across the different systems in the Philippines. Major factors such as Technical, Institutional, Socio Economic and Environmental and specific indicators such cropping/irrigation intensity, ratio of irrigated to service area, ISF collection in Luzon and no ISF in Visayas and Mindanao, viability index, etc were used to assess the level of performance of NIS which ranged from low to high depending on the relative weight and combined effect of the indicators on overall performance. This performance distribution was summarized in Table 54 and Figs 57, 58 and 63.

Objective 2. The following conclusions cover the 2nd Objective which includes a review of NIS project cycle effectiveness, deviation of design area over water delivery service based on engineering measurements and GIS mapping and comparison between pump usage in relation to gravity irrigation system in terms of costs or per irrigated area. Specifically, for the selected 39 NIS cases, the objectives and findings are:

1. Review the effectiveness of the NIS project cycle at each stage, namely identification, feasibility assessment, project selection, project design, construction, operation and maintenance, repairs, restoration, and rehabilitation;

Upon completion of the project, low flow capacity and water losses especially in unlined canals are the main technical reasons for poor water service delivery. So there seems to be lack of effectiveness in the project stages from feasibility to O&M because they were not able to anticipate this problem of siltation which has affected project design and deliverables such as adequate water distribution. In addition, in the absence of staff gauges in most check gates and turnouts, flow measurements are done in the midstream and downstream portion of the main canals or laterals. But these have to be compared with design flows to determine delivery performance ratio, relative irrigation water supply, etc. We need more data on this from the NIA Central Office. Another technical/design aspect included in the analysis consists of the effect of lining on water distribution efficiency which in turn affects water delivery service as most downstream users complain of inadequate water in their areas. Most unlined canals are also silted which reduces the discharge capacity of the distribution systems. This is part of O&M in the project cycle which seems to be ineffective.

New projects with available funds build new infrastructures which could be implemented and laid out according to new design and expected outputs. Rehabilitation of old projects, on the other hand, could have constraints, which may include more rehabilitation expenses, allocated funds have been used up, etc.

In NIS, the trend of focusing on new projects instead of finishing up old/incomplete projects seem to demonstrate the lack of commitment to comply with old project deliverables. But the contract should have been followed until completion. This may be in part due to lack of budget to finish up the incomplete projects or it could be that the feasibility of opening new projects with new budget seem more promising.

The annual growth of new irrigated areas seems to go on a slow pace despite the huge investments introduced for development projects. This may be in part due to the low irrigation potential of the available agricultural lands for expansion which is commonly constrained by slope, soil and productivity limitations. So proper land suitability assessment and classification may be needed to enhance the expansion and growth rate of new irrigation areas. Moreover, land conversion to give way for industrial and residential area expansion seem to be having priority from developers.
Based on the above, a conclusion can be drawn that some stages of the project cycle, most especially O&M, are showing some drawbacks and ineffectiveness as evidenced by canal siltation, too much water losses in unlined canals, non functional gauges and devices, etc.

2. Characterize and explain deviations, if any, from design area and intended water service delivery, based on technical evaluation, engineering measurements, GIS mapping, site visits (including walk-through), and key informant interviews especially of irrigators' association (IA) members;

By using GIS map overlay, the study is able to show the unsuitability of significant proportions of NIS service areas to irrigated rice farming. A representative example from the NIS in Luzon is the case of MARIIS—a huge system with about 80,000 hectares of service area (see erosion map, Figure 3), which shows a reduction in Firmed-Up Service Area (FUSA) by 16 percent because of soil erodibilityalone. Meanwhile, the overlaid maps which incorporates other attributes such as built up areas, slope, soil type, and erodibility, indicate that only 54 percent of the total FUSA in MARIIS is most suitable to irrigated rice agriculture based on GIS mapping (Figure 4). Conversely, 46 percent is unsuitable, which may be the reason why suboptimal yields are obtained within the system.

Similarly, diagnostics are performed for the other systems, with varying estimates of irrigated rice suitability.. GIS maps also documented the degraded state of some NIS watersheds which also accounted for the heavy siltation in these systems.

During the design stage, system performance considered was based from the design standards that all canals were lined, and canal structures were in place. However, after construction, most of the NIS in the country were actually completed if compared to the original design. Most of the deviations were unlined canal and reduced area covered.

Thus, it resulted in the deviation between designed service area and actual irrigated area. Moreover, there were no interactions between design and O&M engineers of irrigation system (David, 2004). Problems related to design during operations were not properly conveyed to the designers. This is evident in the problems encountered by the NIS designed in the 1970s and those designed in the early 2000s which encountered the same operational problems such as canal seepage, siltation and lack of or non functional structures.

On the issue of overlapping of new and old service areas, during the time with ISF, the area is under declared to reduce payment because collection is based on area. With free ISF, areas have increased to have higher subsidy since it is based on area irrigated. To address the overlapping areas, GIS mapping of boundaries should be performed to identify the areal scope and verify justification of each IA. As such no double declaration of areas can occur for subsidy allocation.

Based on the above, it can concluded that there are some deviations/descripancies between design and irrigated areas and this was due to the reduction in service area because of the effects of slope, soil erodibility, soil type and built up areas which were captured by GIS mapping of the watershed. So GIS would be an important tool to determine suitable areas for irrigation project design and development.

3. Characterize and evaluate the incidence of individual pump usage within or in the vicinity of the selected NIS, in terms of effectiveness and cost, in relation to gravity irrigation users.

Pump usage to access water from shallow wells and groundwater has been documented in some NIS cases in Luzon Visayas and Mindanao. It was found that pumping costs per irrigated area are commonly higher than gravity irrigation (e.g. TGIS, Magapit PIS, Libmanan-Cabusao PIS and Solana PIS in Luzon Mambusao RIS, Malinao, Capayas, Bayongan IS in Visayas, etc.). This could be due to the higher costs of fuel or electricity involved in pumping which is closely related to the depth of groundwater source. But ground water is a good alternative for conjunctive use of water resources, that is why maps of ground water potentials are shown in specific NIS cases. Most cases of installation of shallow tube wells can be observed in Visayas and Mindanao NIS such as in Jalaur-Suage RIS, Barotac Viejo RIS, Mambusao RIS, Padada RIS and Pulangui RIS.

An additional feature of NIS evaluation is the inclusion of water quality as an indicator of irrigation performance, considering its effect on rice yield, as evidenced by previous studies. So in addition to water flow measurements, irrigation water quality parameters such as pH, dissolved oxygen (DO), and Electrical conductivity (EC) in main canals and laterals, using water quality kits, was measured in canals whose water is coming from surface and ground water systems. It was found that most of the water in NIS main canals and laterals exhibited reasonably good water quality as reflected in EC <300 uS/cm, DO > 6 ppm and neutral pH (5 to 7). But some cases of low water quality were observed in Luzon especially those pumping ground water (e.g. TGIS) and due to sea water intrusion (e.g. Magapit PIS), where salinity is a problem (i.e. EC is > 300 uS/cm). This is another issue associated with pumping saline shallow wells and groundwater since it can pose serious effects on crop development and yield if not properly addressed.

Another important water quality indicator which affects photosynthesis and thus biomass production is DO which was found to be low (i.e. 6 < ppm) in some NIS case (e.g. downstream of Vaca dam and PDRIS end of downstream. This can be attributed to the thick aquatic vegetation just upstream of the Vaca dam which has caused the reduction of DO downstream. Also, few systems in Iloilo (e.g. Sibalom-Tigbauan RIS), Bohol (e.g. Capayas and Bayongan IS), Davao del Sur (e.g Padada RIS), North Cotabato (e.g MalMar 2), Bukidnon (all NIS) are showing low water quality as per threshold values. The effects on crop development and yield in areas showing low DO and high EC and high pH may have been exhibited in some NIS where rice yield have ranged from 70 to 100 cavans per hectare compared to other sites with high production (i.e. 150 cavan per ha). For instance, in Barotac Viejo and Sibalom NIS sites in Iloilo, yield was as low as 70 and 100 cavans per hectare respectively during first cropping due to high EC (> 400) and high pH (> 7). This was also true in Padada, Davao del Sur and Marbel, Cotabato where yield was only 110 and 80 cavans per hectare respectively and this can be due to the effect of high EC and pH and low Do (<6ppm) to name a few.

Based on the above, it can be concluded that although pumping ground water for irrigation purposes is more expensive than gravity irrigation system, it can however be used for conjunctive use purposes, especially when there is shortage in surface water supply. But its potential should be assessed to establish its safe yield and also consider water quality issues associated with saline groundwater.

Objective 3: Undertake an overall review of the effectiveness of the NIS project cycle based on Objectives (1) and (2) and state recommendations to improve project identification, selection, design, implementation, operations, and maintenance.

On the performance assessment in Cycle 2 covering Visayas and Mindanao NIS, PCA results indicate that around 32% of IAs have low performance compared to 47% in Cycle 1. Only 12% showed high performance in Cycle 1 and it was 23% in Cycle 2 and these are found to be located at the upstream part which receive adequate water supply compared to the downstream part which are the ones showing low performance. So basically, even limited technical data on flows are included in the analysis of indicators, it is already showing that water delivery is one major factor which is causing low performance. The inadequacy of water supply in the downstream part of the system can be attributed again to the technical issue on canal siltation which has reduced its delivery capacity, thus affecting the tail end users. Also, the separate analysis for Cycle 1 and 2 has shown that IAs in Cycle 2 seem to be performing better than IAs in Cycle 1. It should be noted that in Cycle 1, ISF was being collected and collection fee was one of the indicators of performance. Since ISF is free in Cycle 2, it appears that farmers who composed the IAs are quite happy since they can use their savings from free irrigation for other purposes. But some isolated cases reported that with no ISF, funds seem inadequate for managing their canals to control or reduce siltation.

In the development of Irrigation Performance Index (IPI) based on the total sample size of 151 IAs throughout the Philippines, results show that only 22% of the samples have high level of irrigation performance while those having moderate to low performance are 33% and 45%, respectively. Most of the low performing IAs are from Visayas and Mindanao. It should be noted in the integrated analysis, a dummy variable representing ISF (i.e. whether IAs are collecting ISF or not) was used and results imply that ISF is a significant factor that is likely to increase IAs performance. Results also indicate that there still remains a high percentage of the systems which needs improvement in their performance and recommendations on how to address the issues affecting the NIS performance, are suggested in the recommendation.

It should be noted that IPI also reflects the technical and Institutional effectiveness of the project cycle from project identification, feasibility up to O&M since the factors and questions related to these stages of the project are captured in the PCA. Moreover, the IPI is more than just Technical and Institutional dimension of irrigation management because it also includes socio-economic and environmental indicators that affect irrigation systems performance and effectiveness. That is why our irrigation evaluation approach is more comprehensive and encompassing since it covers both the effectiveness and overall performance of the systems based on 4 major indicators.

However, in every approach or methodology, there is of course some drawbacks and limitations. This is addressed in the recommendation section.

6.3.Recommendations

The major technical issues confronting the NIS covered consist of siltation and poor water distribution and delivery especially in the downstream areas. The poor water distribution in most NIS cases is mainly due to water losses especially in earth canals where seepage and percolation losses could be high. Irrigation service is also adversely affected by illegal settlers, dumping of garbage, and illegal pumping. Some recommendations to address the above concerns are as follows:

1. Good watershed management is needed as a preventive approach to address the siltation problems in water courses and, thus, improve discharge capacity of water distribution canals.

Watershed management could also improve water intake into NIS diversion dams. However, the control of the watershed of irrigation systems should be transferred first to the NIA. Watershed management is under the jurisdiction of the Department of Environment and Natural Resources (DENR). NIA should conduct a better assessment of the state of the watersheds for each NIS project and properly factor the results in the system design and O&M (as short- and medium-term recommendations). Watershed management is already part of the NIA's charter. However, it will require allocation of substantial resources and not just "coordination" with the DENR. A more comprehensive approach called Integrated Watershed Management (IWM) can be adopted with the following objectives: (1) control damaging runoff and degradation and, thereby, conserve soil and water; (2) protect and conserve the watershed for more efficient and sustained production; (3) protect and enhance the water resource originating from the watershed; (4) control soil erosion in the watershed and reduce the effect of sedimentation in downstream areas, including water courses and canals and (5) increase infiltration of rainwater and improve soil and ground water recharge, wherever applicable.

2. In view of the perennial problem of poor water distribution in NIS cases due to lack of maintenance and siltation of main canals and laterals, it is being contemplated to adopt pipe irrigation system in NIS.

Based on Table 57, it is worth exploring on investing for pipe network since the cost of maintenance is low, and conveyance/distribution efficiency is high. Also, evaporation loss especially during summer is basically nil since it's an enclosed system. But the return to investment can be obtained after several years of operation. A detailed cost analysis is needed to estimate the investment needed and when the cost will be recovered. A pilot project is recommended to establish its feasibility and viability with respect to economic, technical and social implications. Also, in case pipe use is preferred, it is recommended to implement pipe system in small laterals and farm ditches (main and supplementary). Pipe system will support land consolidation. This is to facilitate farm operations, especially mechanization activities.

3. Canal and its appurtenant structures require additional maintenance and rehabilitation (i.e., lining of canals) to improve efficiency in water allocation and distribution from upstream to downstream users.

NIA should allocate realistic resources for O&M and formulate effective policies and incentive systems, so as not to defer O&M until the problem becomes a major rehabilitation project. The target is to establish the system condition near its design condition (i.e., conveyance losses to its minimum and control structures working properly). The poor water distribution in most NIS cases is mainly due to water losses, especially in earth (unlined) canals. However, canal lining, although effective in reducing water losses, should be evaluated to confirm its long-term efficiency in comparison with unlined canals. Some background papers from the Mapping System and Services for Canal Operation Techniques or MASSCOTE showed that 2–3 years after lining, the efficiency of lined canals are no different from unlined canals.

The Irrigation Performance Index (IPI) has also shown that the technical aspect of irrigation management is a major indicator of performance which implies that O&M should be given high priority by NIA especially focusing on reduction of siltation (as per # 1), reduction of water losses via pipe use or canal lining (as per # 2 and 3) and proper monitoring of water flows (as per # 4). With these measures, adequate and equitable water distribution and allocation will be enhanced.

4. Water flow is a basic measure critical to system management. However, this information could not be obtained due to the non-operational check gauges.

NIA should have a regular monitoring of structures so timely repair or replacement, of damaged or non-functional devices are done on schedule. Water quality on the other hand which are characterized by some indicators such as dissolved oxygen (DO), pH and electrical conductivity (EC) which is related to salinity level, are showing acceptable levels in most NIS in Cycle 2. However, this should be checked seasonally and should be part of monitoring and evaluation programs of NIA to become a basis for policy formulation. This is to avoid water quality deterioration in the future which could have an effect on yield as was reported in Literature and somehow linked in this study.

5. The use of GIS analysis was useful in mapping the location of structures, measurements, and spatial analysis of erosion, groundwater potential, flooding, and distribution of IA performance.

GIS applications can be further enhanced in targeting interventions (i.e., in helping the NIA and the Department of Agriculture improve land productivity) and in determining suitable areas for irrigation. It can also be used as a tool for project identification, selection, design and implementation based on suitability of lands for irrigation development as reflected in slope, soil erosion and ground water potential maps.

On the issue of overlapping of new and old service areas, this can be related with the ISF. During the time with ISF, the area is under declared to reduce payment because collection is based on area. With free ISF, areas have increased to have higher subsidy since it is based on area irrigated. To address the overlapping areas, GIS mapping of boundaries should be performed to identify the areal scope and verify justification of each IA. As such no double declaration of areas can occur for subsidy allocation.

6. Estimation of ground water recharge seems to be out of scope in the present study since it needs more time and intensive data gathering related to groundwater balance components such as rainfall, runoff, evapotranspiration, subsurface inflow and outflow and deep percolation and upward flux. This entails another independent study since we need to have the measured data from the NIS sites covered. In this regard it is proposed to undertake a separate research project in the future which focuses on detailed hydrologic data gathering and modeling of ground water balance.

Moreover, there is a need to reevaluate the definition of potential irrigable areas, including the assessment of water supply sources and comprehensive land use plans of the local government units. In estimating potential irrigable areas, improved data collection and management is required. In all the feasibility studies of all the NIS in the country, data adequacy and quality are always the constraints to proper estimation of irrigable areas. Although soil texture and land suitability to certain type of crops were being considered during the design, reliable and adequate data in the field were not collected. Science-based information hydrologic data should include smaller rivers and creeks. Water supply and water demand projections using new climate change scenarios can be useful in identifying new and potential sites for irrigation development.

7. It was mentioned that the Irrigation Performance Index (IPI), which is determined by multi variate analysis of all the factors that affect irrigation system performance, could have some limitations. The main drawback in estimating IPI is the adequacy of data related to the numerous factors under each principal component or major indicator (i.e., Technical, Institutional, SocioEconomic and Environmental). In effect, if those data are not sufficient or the quality is in question, then it could render the findings to be not conclusive. Therefore to address this limitation and improve the analysis and results, we should consider in future studies/analyses the seasonal variation in water supply and quality as well as increase and enhance water flow and quality measurements by upgrading structures/devices, and further improve questionnaires to cover all aspects of irrigation management.
8. Regular monitoring and proper implementation of policies related to illegal activities that affect irrigation system functionality (e.g. illegal settlers, pumping, and waste disposal) should be enforced and penalties are meted to violators).

The above recommendations somehow reflect the 3rd Objective of the NIS component, that is, state recommendations to improve project identification, selection, design, implementation, operations, and maintenance. It was evident that there was some ineffectiveness in each stage of the Project Cycle with more drawbacks being encountered or showing up in the O&M phase of the Project Cycle. Specifically, the observed problems in almost all NIS cases in the country are related to O&M which include non operational canal structures/devices, canal siltation,and reduced water flow capacity, among others, which resulted in inequitable distribution of water. The downstream users are the ones mostly affected since they don't usually get enough water or non at all, when it is most needed. In effect these areas showed poor irrigation performance across all systems which often led to low yield and poor income of the farmers. So to address this problem, that is to improve O&M of the project cycle, NIA needs to prioritize the recommendations above, in terms of fund allocation and proper implementation.and monitoring.

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Glossary

Agriculture and Fisheries Modernization Act or AFMA (RA 8435) - It is a policy instrument defining measures to modernize Philippine agriculture for the country to compete in the global market. The law has broad based provisions covering: 1) production and marketing support services; 2) human resource development; 3) research development and extension; 4) rural non-farm employment; 5) trade and fiscal incentives; and 6) general provisions.

Communal Irrigation System (CIS) - It is an irrigation system that is managed by a bonafide Irrigator's Association.

Control Structures - ensure adequate water levels, dissipate energy, provide accurate distribution, and deliver water to the field without erosion.

Conveyance Loss - Loss of water from a channel or pipe during transport, including losses due to seepage, leakage, evaporation, and transpiration by plants growing in or near the channel.

Conveyance Structures - They are used to transport irrigation water from the source to the farm ditches

Crop Irrigation Requirement - Quantity of water, exclusive of effective precipitation, that is needed for crop production.

Deep Well Pump - A pump designed for pumping water from wells with water levels more than about twenty five feet below the pump location. Such pumps are designed so that the pump cylinder is near the well water level and the water is forced to the surface rather than being sucked to it.

Discharge - The volume of water pumped per unit time.[ASAE] the area where conveyed material is discharged from the machine.

Dissolved Oxygen (DO) - indicates the amount of oxygen dissolved in a body of water.

Effective Rainfall - It is the total rainfall minus the amount which cannot be stored or used in the paddy field.

Electrical Conductivity (EC) - a measure of the water salinity or the total salt content of water based on the flow of electrical current through the sample.

El Niño – It is the unusual warming in the Central and Eastern Equatorial Pacific. It occurs in the Pacific basin every 2-9 years, usually starts between December to February. It causes drought and delays the onset of rainy season.

Emergency Spillway - Auxiliary channel which transmit flood water exceeding the capacity of the principal spillway.

Evapotranspiration - The combined effects of evaporation from the soil and plant surfaces and transpiration from plants.

Farm Water Requirement - It is the sum of irrigation requirement and farm ditch losses.

Flooding frequency – How often the farmers have ever experienced flood in their fields.

Flood Irrigation - Method of irrigation where water is applied to the soil surface without flow controls, such as furrows, borders or corrugations.

Free Irrigation Act [Republic Act No. 10969] - an act providing free irrigation service, amending for the purpose Republic Act No. 3601, as amended, appropriating funds therefor and for other purposes

Groundwater - underground water that has come mainly from the seepage of surface water and is held in pervious rock; can be a source of useable water through certain extraction methods

Inverted Siphon - A closed conduit with end sections above the middle section used for crossing below a depression or under a highway.

Irrigable Lands - Are lands which display marked characteristics justifying the operation of an irrigation system.

Irrigated Area – (Irrigable Area) Area capable of being irrigated, principally as regards to availability of water, suitable soils, and topography of land.

Irrigation - It is the application of water to soil for the purpose of supplying moisture essential to plant growth.

Irrigation Check - Small dike or dam used in the furrow alongside an irrigation border to make the water spread evenly across the border.

Irrigation Efficiency - The ratio of the average depth of irrigation water that is beneficially used to the average depth of irrigation water applied, expressed as a percent.

Irrigation Scheduling - Careful choice of irrigation application rates and timing to help irrigators maintain yields with less water.

Irrigation System - All equipment required to apply water to the design area.

Irrigation Water Requirement - It is the quantity of water, exclusive of precipitation required to maintain desired soil moisture and salinity level during the crop season.

Irrigator's Association (IA) - Is an association of farmers within a contiguous area served by a National Irrigation System or Communal Irrigation System.

La Niña - characterized by unusually cold surface temperatures of the ocean. It is associated with anomalies in rainfall, temperature, and tropical cyclone activities. It favors the formation of tropical cyclones over the western Pacific, thus increasing the number of tropical cyclones.

Magna Carta of Small Farmers (RA 7607) - aims in realizing equitable distribution of benefits and opportunities through the empowerment of the small farmers. The law recognizes the country's responsibility for the welfare and development of small farmers by giving them support in attaining their socioeconomic goals. The law encourages the participation of small farmers, farm workers, farmers' cooperatives and organizations to enjoin in the planning, organization, management and implementation of agricultural programs and projects.

Main and Submain - The water delivery pipelines that supply water from the control station to the manifolds.

Main Canal - Is the channel where diverted water from a source flows to the intended area to be irrigated.

National Irrigation System (NIS) - Is a major irrigation system managed by the National Irrigation Administration.

Parshall Flume - A calibrated device used to measure the flow of water in open channels, based on the principle of critical flow (formerly called the improved Venturi flume).

Peak flow (q_p) - It is used to determine the magnitude of floods and a valuable consideration in the design of structures.

Peak/Off-peak Rates - Rates charged in accordance with the most and least popular hours of water use during the day.

pH - is a measure of the acidity or alkalinity of water. Water is acidic if pH is between 1 to 7, whereas alkaline for the range between 7 to 14

Secondary Canal - It is the channel connected to the main canal which distributes irrigation to specific areas.

Shallow Tubewell (STW) – a tube or shaft vertically set into the ground for the purpose of bringing groundwater to the soil surface from a depth of less than 20 meters by suction lifting.

Siltation – is the pollution of water by the increased concentration of suspended sediments such as silt

Spillway - Is a structure for passing out water not needed for storage or diversion.

Surface Irrigation - Broad class of irrigation methods in which water is distributed over the soil surface by gravity flow.

Total dissolved solid (TDS) - represents the total amount of salts in the water.

Turnout - It is the structure built at the point where a farm ditch branches out from a distributary canal to regulate or control the water flowing into the farm ditch.