FINAL REPORT for APN PROJECT

Project Reference Number: CBA2011-18NSY-Penalba

AWARENESS RAISING AND CAPACITY BUILDING ON ALTERNATIVE WATER MANAGEMENT FOR COMMUNAL IRRIGATORS' ASSOCIATIONS IN THE PHILIPPINES

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Awareness Raising and Capacity Building on Alternative Water Management Strategies for Communal Irrigator's Associations in the Philippines

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Final Report submitted to APN

OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

The Philippines usually incurs severe crop losses caused by drought and typhoon-induced flooding. Much of these losses could have been reduced or avoided through effective water management and social mobilization for efficient irrigation systems operation and maintenance (O&M). Building the capacity of irrigators' associations, that are tasked to manage irrigation systems, is therefore crucial. This project aims to improve farmers' awareness and skills in irrigation water management, application of climate forecast in their decision making. It engaged water management technologists, agronomists, and extension experts in bridging the gap between the science-based water management techniques and traditional farmers' practices.

Objectives

The general objective of the project is to increase awareness, knowledge and capability of communal irrigators' associations (CIAs) on alternative irrigation water management, climate forecast application, rice production systems and social mobilization, and recommend measures to replicate good practices in other areas of the country. Specifically, it aims to: 1) assess the irrigation water management practices of CIAs and the problems they encountered; 2) conduct lectures and workshops on alternative water management strategies and social mobilization; 3) assist CIAs in preparing alternative water management and institutional development plans for optimum irrigation water allocation, particularly, during extreme weather events; and 4) recommend measures to replicate good practices in other areas of the country.

Amount received and number years supported

The Grant awarded to this project was:
US$ 30,000 for Year 1, 2011-2012

Activities undertaken

- *Situational analysis* – Baseline information (e.g., water management practices and experiences during extreme weather events) on 10 CIAs in the provinces of Laguna, Rizal, Batangas, and Quezon were collected to select potential partner IAs for the project. The 5 CIAs that were chosen are: the San Juan Communal Irrigator's Association and Quilo-Quilo South Irrigator's Association in Batangas; San Lorenzo Multi-Purpose in Rizal; Callejon-Del Valle Irrigator's Association and Tubig Biyaya Irrigator's Association in Quezon.
- *Awareness raising and capacity building* – Members of the CIAs were invited to participate in lecture-seminars that covered the following topics: 1) rice production and water use; 2) alternative wetting and drying and aerobic rice; 3) operation and maintenance of communal irrigation system (CIS); 4) effective water management under different environmental conditions; and 5) assessing the feasibility of alternative water sources.
- *Vulnerability assessment, water management and institutional development planning* – The Project Team conducted focus group discussions (FGDs) and key informant interviews to assess the vulnerability of the CIAs and CIS based on the following: natural capital, human capital, technical aspects, economic capacity and policy capacity. Information generated from the vulnerability assessment combined with the lessons learned from the seminar-workshops, were used in the identification of problems, needs, and possible solutions that were incorporated in the Irrigation Management Plan that was prepared by each participating CIA.
- *Presentation of water management and institutional development plans* –The participants were convened to present their respective plans to other partner CIAs, and to a panel of critics to solicit

comments and suggestions. This activity also enhanced the awareness and capability of each CIA on various social, technical and practical issues related to CIS management.

- *Plan of implementation* – The Plans were presented to the CIA members. At this stage of the project, the CIAs were expected to set-up mechanisms to implement the Plan.
- *Monitoring and evaluation of plan implementation* – The Project Team regularly monitored the CIAs' progress in the implementation of their plans.
- *Dissemination and outreach* – The information generated and outcome of the project will be shared with concerned CIA, NIA and LGUs for appropriate action, such as possible replication to other areas within their domains. Policy briefs, journal articles and technical papers will also be prepared.

Results

- On the average, the CIS covers about 100 ha of rice farms that are usually serviced by run-off-the-river type dams constructed by the NIA. The operation and maintenance of CIS are turned over to IAs upon project completion subject to cost recovery arrangement. Each CIA membership is around 100 rice farmers.
- The communal irrigation systems are between 10 and 30 years old, and mostly in need of rehabilitation. The CIAs maintain their dam/head gate and conduct periodic rehabilitation with their own resources or from external assistance. Maintenance of irrigation canals are done by weeding and removal of trashes, and dredging.
- Quilo-Quilo South could irrigate 100% of its service area while the San Lorenzo and the Tubig Biyaya irrigation systems could irrigate around 90%. On the other hand, the CIS of Bancuro and Callejon-Del Valle could only irrigate around 43%, due to unfinished construction of canals in Bancuro and water supply shortage in Callejon-Del Valle, being at the tail end of water source. There are two cropping seasons every year in all locations. The irrigation schedule within the CIAs is fixed within each season, except in Tubig Biyaya where water distribution is rotational.
- Bancuro, San Lorenzo and Tubig Biyaya CIAs experienced increases in rainfall while Quilo-Quilo South had reduced rainfall over the years. Callejon-Del Valle, on the other hand, did not observe any rainfall fluctuations. However, all CIAs stated that the onset of rainy season, relative to their usual cropping calendar has changed, is either delayed or advanced. Farmers can cope better with advanced than delayed rainfall because they can easily adjust their planting period. Members of San Lorenzo MPC experienced more intense typhoons and severe flooding, while Quilo-Quilo South CIA members experienced longer dry seasons.
- All CIAs described their soil as clayey. Bancuro and San Lorenzo members see this as an advantage since water will not easily percolate. On the other hand, Quilo-Quilo South and Tubig Biyaya members claimed that it has negative effect, especially during rainy season as rice plant tends to lodge in heavy clay soil.
- Except for Tubig Biyaya, CIA members have insufficient training on irrigation management and insufficient knowledge on climate change and its impacts. Participation of members on meetings, except for Tubig Biyaya CIA is also limited. Farmers' attendance to seminars and lectures should be reinforced, wherein they can be exposed to the updates on new rice production technologies to improve their yields.
- There are existing policies that are being observed in each organization regarding water sharing arrangement, irrigation scheduling and meetings. Across the organizations, water sharing policies are clear, but are sometimes not strictly implemented.
- Bancuro Communal and Tubig Biyaya CIAs have 100% irrigation service fee (ISF) collection efficiency, while San Lorenzo MPC and Quilo-Quilo South had 60% and 70% ISF collection efficiency, respectively.
- A common problem experienced by the three CIAs (i.e., Bancuro, Quilo-Quilo South and San Lorenzo) is the water distribution conflict. To solve the problem: 1) Bancuro assigned water tenders in each sector to monitor the use of irrigation water of the members and practice

alternative wetting and drying; 2) Quilo-Quilo South conducts dialogues with members; while 3) San Lorenzo is planning to install STWs to as an alternative source and to repair canals.

- Erosion and siltation in most irrigation system is also a common problem to the CIAs. This was attributed to the deforestation in the watershed areas and not fully concreted irrigation canals. Uncemented canals lead to rapid drying up, thus, increased percentage of irrigation water lost. The CIAs claimed that reforestation activity in partnership with the local government units and other sectors such as private companies, and youth organizations can be one of the solutions to minimize the problem.
- Polluted water coming from piggeries is a problem experienced by Quilo-Quilo South CIA. The CIA has already reported this to the municipal governments and NIA. Laws and policies of the CIAs can be integrated in the list of the policies of the *barangay* to address pollution issues. It is also suggested that Irrigation water should also be analyzed along with the plan to have a soil analysis.
- The CIAs are generally in need of funds to tap alternative sources of irrigation water, such as shallow tube well and small water impounding projects, and to rehabilitate their irrigation systems. The CIAs are advised to exert more effort in sourcing government and external fundings.

Relevance to the APN Goals, Science Agenda and to Policy Processes

The project focused on awareness-raising, skills development, and information dissemination on effective irrigation water management, which are deemed relevant and consistent with APN's focus on global change and its concerns for scientific capacity development for sustainable development, awareness raising and dissemination activities.

This project has several components that are in line with APN's CAPaBLE third strategic plan, particularly on scientific capacity development and science policy agenda. The awareness-raising and capacity building activities undertaken for the CIAs and LGUs were aimed to improve their decision-making within the context of sustainable development issues such as water conservation and water demand reduction.

The policy questions that this project tried to address are:

1. Given the expected changes in water resource availability associated with climate change, what changes in rice production schemes (e.g., variety, cropping system, cropping schedules) can DA promote? What capacity building programs can NIA implement to help CIAs adapt to the changing climatic conditions? What programs can be implemented to harness the CIA members' full cooperation when contingency plans are implemented?
2. What will be the institutional arrangements between NIA, CIA and LGU, and the mechanisms that will affect the phasing-in of LGUs in irrigation system management? How can the gains of this initiative be replicated and sustained in the long-term? How can the trained CIA and LGU officials continue to effectively apply the knowledge they gained and operate the response system that will be set-up to mitigate climate change impact on irrigation service delivery?

Self evaluation

The project attained its objectives to increase the awareness, knowledge and capability of CIAs on alternative irrigation water management, climate forecast application, rice production systems and social mobilization. Aside from the lectures provided by the experts, the vulnerability assessments and the experiences that these CIAs shared helped in identification of the most appropriate recommendations and good practices they need to improve their capacity as an organization and as individual farmers.

Additional lessons from a successful CIA also helped in providing the partner IAs an idea on how to effectively manage their system through availment of financial support from other sources. It is interesting to note the crucial importance of cooperation and proper coordination within and outside the organization in improving their organization to positively benefit the farmers and users.

The research acknowledges that sustained implementation of the Irrigation Management Plans may encounter problems due to the weak organization and the difficulty in mobilizing the CIA members, particularly among the share tenants. It is therefore important to bolster the interest and commitment of members through proper policies and several systems that the IAs may adopt. Through the project, the exchange of knowledge and experiences has greatly helped the partner CIAs in increasing their awareness and skills on effectively managing their systems.

Potential for further work

The outcomes of this project have instigated to disseminate information to further help the partner CIAs in improving their management skills and capacity. This has led to writing a handbook that will be circulated to IAs to provide them with an overview and situational analysis of irrigation systems, as well as guide them in improving their systems, making strategic plans and adopting proper adaptation options and technologies in irrigation management.

A review of irrigation policies is a potential area for further work. A more socially inclusive policy is needed in order to properly address the needs of irrigation systems and IAs. It is important to look at awareness raising and capacity building of IAs and not just the Local Government Units.

Publications (please write the complete citation)

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References

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TECHNICAL REPORT

Preface

The Philippines usually incurs severe crop losses caused by drought and typhoon-induced flooding. Much of these losses could have been avoided through effective water management and social mobilization for efficient irrigation systems operation and maintenance (O&M). Building the capacity of irrigators' associations, which are tasked to manage irrigation systems, is therefore crucial. Within the context of managing irrigation systems under normal as well as adverse conditions, this project aimed to improve farmers' awareness and skills in irrigation water management and application of climate forecast in their decision making. It engaged water management specialists and agronomists to bridge the gap between science-based and more efficient water management techniques and farmers' traditional practices.

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1.0 Introduction

1.1 Rationale

Most Asian countries use 80-90% of their developed water resources to meet the water requirements of cultivated crops (Sharma, 2006). Rice, which is considered the most important food crop in Asia, requires substantial amount of water but the decreasing availability of water for irrigated rice threatens food security in general, and the livelihood of farmers in particular.

In the Philippines decreasing availability of water is exacerbated by typhoon-induced flooding that caused severe crop losses. Much of these losses could have been avoided through effective water management and social mobilization for efficient irrigation systems operation and maintenance (O&M). However, much of the water management technologies that have been developed are not widely disseminated and adopted in the country (Lampayan et al., 2005).

The Communal Irrigator's Associations (CIAs) are the key actors in water management, and therefore could also have the crucial roles in the adoption of related technologies. The CIA refers to an association of farmers within a contiguous area by a communal irrigation system (CIS). A CIS has a service area of less than 1,000 ha. As of 2007, there were 6,360 organized CIAs with almost 780,161 farmer-members (www.nia.gov.ph). Existing government policies [e.g., Republic Act (RA) No. 8435, RA No. 7160, and Executive Order No. 718] provide for the transfer of irrigation systems management to IAs.

The on-going irrigation management transfer program (IMT) in the Philippines has a capability building component (Ofrecio, 2006). Considering the vulnerability of water supply to climate change as manifested by extreme climate events, however these training activities may not be adequate or appropriate. In 2008 and 2009, strong typhoons hit many areas of Luzon causing crop damages of about PhP15-20 billion, while the long dry-spell caused about PhP 12 billion of damage to agriculture in 2010 (www.ndcc.com). Knowledge and skills about irrigation water supply management and utilization of climate forecast are critical in the light of climate disturbances. Uptake of alternative adaptation measures to cope with irrigation-related problems will therefore depend on the knowledge and capability of individual farmers and the organized CIAs.

1.2 Objectives

Building the capacity of CIAs is crucial in minimizing crop losses and attaining food security. Thus, the project aimed to improve farmers' awareness and skills in irrigation water management and climate forecast application. It engaged the expertise of water management specialists and agronomists to bridge the gap between science-based water management techniques and farmers' practices. Specifically, the project aimed to: 1) assess the irrigation water management practices of CIAs and the problems they encountered; 2) conduct lectures and workshops on alternative water management strategies and social mobilization; 3) assist CIAs in preparing alternative water management and institutional development plans for optimum irrigation water allocation, particularly, during extreme weather events; and 4) recommend measures to replicate good practices in other areas of the country.

2.0 Methodology

2.1 Scope

This participatory action research project covered five IAs that operate CIS in Laguna, Rizal and Quezon. A CIS is small-scale system, which irrigates less than 1000 ha of land (www.nia.gov.ph). Preliminary data on operating CIAs were validated on the ground, and the CIA's willingness to participate in the project were determined before the list of partner CIAs was finalized. The cooperation of local NIA staff who supervises the CIA and the LGU was also solicited. The five CIAs chosen as partners for the project were: San Juan Communal Irrigator's Association and Quilo-Quilo South Irrigator's Association in Batangas, San Lorenzo Multi-Purpose in Rizal, and Callejon-Del Valle Irrigator's Association and Tubig Biyaya Irrigator's Association in Quezon.

2.2 Major Project Activities

To attain the objectives of the project, a mix of approaches was employed to raise the awareness of CIA members about alternative water management technologies, development of technical and practical skills on the application of these technologies, preparation of a water management and institutional development plan that maybe applied during incidence of climate variability and extremes (Table 1).

Table 1. Project methodology for each objective.

Objective	Methodology
Assess the irrigation water management practices of and problems encountered by Communal Irrigator's Associations (CIAs)	• Focus group discussions, key informant interviews, and review of secondary data and reports were done. • Situational analysis using baseline information on the CIA and CIS, current water management and rice production practices, social mobilization schemes, farmers' knowledge on alternative technologies, and farmers' experiences during extreme weather events as well as problems and adaptation measures were collected through interview with NIA and CIA officials.
Conduct lectures and workshops on alternative water management strategies and social mobilization	• Topics include: 1) rice production and water use; 2) alternative wetting and drying and aerobic rice; 3) operation and maintenance of communal irrigation system (CIS); 4) effective water management under different environmental conditions; and 5) assessing the feasibility of alternative water sources.
Assist CIAs in preparing alternative water	• Focus group discussions, key informant interviews, and review of IA records were done.

management and institutional development plans for optimum irrigation water allocation, particularly, during extreme weather events	• Vulnerability assessment of the CIAs and the CIS were based on: natural capital, human capital, technical aspects, economic capacity, and policy capacity. • Vulnerability assessment results combined with the lessons learned from the seminar-workshops were used in the identification of the problems, needs, and possible solutions. • Irrigation management plan for each participating CIA was prepared.
Recommend measures to replicate good practices in other areas of the country	• Results of the project will be forwarded to CIA, NIA and LGUs for appropriate action, and for possible replication in other areas. • Policy briefs, journal articles and technical papers will also be prepared.

A number of activities were lined-up to attain project objectives. The basic principles that guided the conduct of these activities are sharing of knowledge, lessons and experiences, capacity building, self-reliance, and community participation and interaction. Most of these activities were done by the project participants on site, with the research team that mainly acted as facilitators and resource persons.

a. *Profiling of CIS/CIAs* **–** To be able to contextualize other project activities, baseline information on the CIA and CIS, current water management and rice production practices, social mobilization schemes, farmers' knowledge on alternative technologies, and their experiences during extreme weather events, as well as problems and adaptation measures, were collected through interview with NIA and CIA officials. Secondary data on policies, programs and accomplishments were also collected. A total of 10 CIAs, i.e 3.in Laguna, 2 in Rizal, 2 in Batangas, and 3 in Quezon were visited. From the 10 CIAs initially identified, five met the selection criteria and were chosen to become partner CIAs of the project. One of the 10 CIAs was also designated as a model, in which experiences by this model CIA could be use by the other CIAs in developing their irrigation management plans.

b. *Vulnerability assessment* – More detailed data and information were collected by the project team, in collaboration with the CIA, NIA and LGU. The project team conducted focus group discussions (FGDs) and key informant interviews to assess the vulnerability of the CIAs and the CIS based on the following indicators: natural capital, physical capital, human capital endowment, social capital and institutional capability, and economic capacity.

The CIA, LGU and NIA officials were interviewed to gather more in-depth information on CIA's irrigation service delivery programs and policies, irrigation system O&M, social mobilization, institutional linkages, level of awareness on climate change and climate change adaptation, knowledge and skills in responding to extreme weather events, collection and interpretation of scientific data regarding groundwater extraction and surface flow estimation, policy-making processes, and problems encountered.

The FGDs with farmers and CIA members were conducted to solicit information on their level of knowledge and skills on: alternative water management strategies, rice production practices; cropping systems, water management policies (e.g., water scheduling) ISF collection; extent of cooperation and commitment regarding the O&M of irrigation systems, their attitudes and perceptions about water scheduling, financial status (e.g., ISF collection rate, status of loan with NIA re- dam construction cost recovery, overall fiscal health of CIA), and water management problems encountered. Secondary data or information on NIA's and LGU's irrigation development or management programs and policies, accomplishments, systems O&M, and measures to respond to extreme weather events were also collected.

Data collected were processed and analyzed using a standard format to facilitate comparison across CIAs and integration of research results. These were used to assess the vulnerability of the study sites to irrigation water allocation problems, and the adaptability of various rice production systems.

c. *Awareness raising and capacity building* – Experts such as agricultural engineers and agronomists were invited to lecture and demonstrate various water management, water-saving and rice production technologies. Seminar-workshops were held on-site so that more CIA members can participate in the seminar-workshop, contrary to the usual practice of bringing together all officials of participating organizations and holding similar activities off-site such as in UP Los Baños. A total of five seminar-workshops were conducted for this project, participated by a total of 207 farmers. In every seminar, five topics were discussed, namely: i) rice production and water use; ii) alternative wetting and drying and aerobic rice; iii) operation and maintenance of CIS; iv) effective water management under different environmental conditions; and v) assessing the feasibility of alternative water sources.

d. *Water management and institutional development planning* – The water management and institutional development plans prepared by each participating CIA were based on a careful assessment of the biophysical, agro-climatic and socio-economic conditions in the study sites.

Vulnerability assessment results combined with the lessons learned from the seminar-workshops were used in the identification of the problems, needs and possible solutions that were incorporated in the irrigation management plan that each participating CIA prepared. The research team assisted the CIAs in preparing the plans, that will serve as their guide to improve their water allocation, given the challenges brought about by climate change, water scarcity and changes in government policies.

Based on the vulnerability assessment, farmers' level of knowledge and skills, problems, and appreciation of climate-responsive water management technologies and rice production technologies were identified as well as characterized.

Learnings drawn from the lectures enlightened the farmers on the scientific basis of the alternative technologies on water management and rice production. These learnings were inputted in the preparation of the CIA's water management plan to address the problems they encountered.

e. *Presentation of water management and institutional development plans* – After the plans were prepared, the participants were convened to present their respective plans to fellow CIAs and a panel of critics. The panel of critics shared their comments and suggestions on the technical and practical feasibility of the plans. This gathering was also a venue for sharing knowledge, learnings and experiences that could enrich the awareness and capability of each CIA on various social, technical and practical issues related to planning, resource mobilization and CIS management. One of the successful IAs was also invited to share their irrigation management, practices and operation from which partner CIAs can pick-up lessons or practices that are adoptable for their own organization.

f. *Plan implementation* – The Plans were presented to the CIA members for their information and to initiate implementation. At this stage of the project, the CIAs were expected to set up plan implementation mechanisms, such as creation of working committees and designation of each member's roles and responsibilities.

g. *Monitoring and evaluation of plan implementation* – Implementation of the Plans was monitored by the project team to assess the effectiveness of the technical and social mobilization strategies, and assist the CIAs in introducing the necessary remedial measures.

h. *Dissemination and outreach* – Results of the empirical and secondary data analyses as well as the project recommendations, were forwarded to CIA, NIA and LGUs for appropriate action. Lessons and experiences that can be drawn from this project can be replicated by NIA and the LGUs concerned in their respective areas of jurisdiction. Policy briefs, journal articles, technical papers, and a Handbook on Irrigation Management Planning for Communal Irrigation System in the Philippines were prepared for dissemination to concerned audiences or end-users.

The major outputs of the project that can be disseminated to different audiences for information and appropriate action, include: 1) compendium of lectures on various water management technologies, 2) vulnerability assessment of the study sites, 3) CIAs' irrigation management plan that addresses both water resource management and institutional development, and 4) handbook on irrigation management planning. Policy briefs/paper and scientific/technical papers, and reports will also be published. These reports will be presented to the local communities and concerned organizations for their information, and to raise their awareness about the vulnerability of their situation and the importance of working together to take appropriate action. Dissemination shall also be done through lectures or oral presentations in symposium, scientific conferences, meetings with LGU organizations or through publication in print and electronic media.

3.0 Results and Discussion

3.1 Profile of the Study Communal Irrigator's Associations

The chosen five study CIAs were: Bancuro Communal Irrigator's Association and Quilo-Quilo South Irrigator's Association in the province of Batangas, San Lorenzo Multi-Purpose Cooperative in Rizal, Callejon-Del Valle Irrigator's Association and Tubig Biyaya Irrigator's Association in Quezon (Table 2). The oldest CIA was Tubig Biyaya having been organized in 1960, while the youngest was Bancuro which was organized in 2008. Tubig Biyaya was registered with the government agency concerned only in 1996. On the other hand, Quilo-Quilo South CIA and Callejon-Del Valle CIA which were the second and third oldest CIAs studied were organized and registered in the same year, i.e. in 1990 and 1992, respectively. San Lorenzo MPCI was originally organized as a farmer's association in 1960, then transformed into multi-purpose cooperative in 2002, and was in the process of being converted to a communal irrigator's association during the time of the study.

The target service area of all CIAs were within the range of 100-118 ha. The Bancuro CIS has a slightly bigger target service area (118.185 ha), while Quilo-Quilo South CIS has the smallest service area (100 ha). In terms of actual area irrigated, Quilo-Quilo South and San Lorenzo had the biggest (100%), while Bancuro and Callejon-Del Valle have very low irrigation service efficiencies. This was attributable to the unfinished construction of canals in one sector in Bancuro and the water supply shortage in Callejon-Del Valle since it is located in the downstream portion from water source that also served Quilo-Quilo CIA.

The Callejon-Del Valle IA was the biggest in terms of membership with 105 members, while the Bancuro CIA was the smallest with only 41 members. However, actual number of active members Bancuro CIA was higher than Callejon-Del Valle CIA. About 80% of Bancuro CIA members were active compared to only 20% of Callejon-Del Valle's members. The Tubig Biyaya and Quilo-Quilo South have high proportion of active members.

Majority of the members of Callejon-Del Valle (64%), Bancuro (75%) and Quilo-Quilo South (77%) CIAs, and San Lorenzo MPC (70%) were owner-operators while the rest were share-tenants. The reverse is true in Tubig Biyaya CIA, wherein only a small proportion (13%) of the members were owner-operators and majority were share-tenants. The usual sharing arrangement between the land owner and the tenant was 50-50. In Bancuro, the landowner and the tenant get an equal share of the harvest, with the landowner sharing in the cost of production.

It was earlier thought that the farmer members' land tenure status is an important factor that affects payment of irrigation service fee. The poor ISF collection in Callejon-Del Valle was attributed by its officers to the predominance of share-tenants among its members, who are assumed to have low paying capacity, having only 25% share of the harvest. However, the high ISF collection rate of Tubig Biyaya CIA contradicts the earlier mentioned assumption. Thus, member's land tenure status per se is not the main factor that affects the performance of the organization. Instead Callejon-Del Valle's low performance as an organization can be attributed to the observatin that most of its members were not actual tillers, do not reside in the village, and were not fully aware of CIA policies and activities.

The service area of the study CIAs can transcend political boundaries. For instance, Bancuro CIA covers three *barangay*s while San Lorenzo MPC covered two *barangay*s. In contrast, the other CIAs cover only one *barangay*.

Table 2. Profile of the Communal Irrigator's Association (CIA) covered by the project

Particular	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Location	San Juan, Batangas	Padre Garcia, Batangas	Pililia, Rizal	San Antonio, Quezon	Pagbilao, Quezon
Year organized	2008	1990	1960 (Farmer's association) 2002 (Multi-purpose cooperative)	1992	1960

Year registered with government office	2008	1990	2002	1992	1996
Service area (ha)	118.185	100	110	105	100
Actual area irrigated (ha)	51	100	100	45	92
Number of farmer members	35	100	97	105	79
Proportion of active members (%)	86	80	79	50	73
Land tenure status of members					
▪ Landowner (%)	75	77	70	64	13
▪ Tenant (%)	25	23	30	36	87
Number of *barangays* covered	3	1	2	1	1

3.2 Agricultural Production and Water Management Practices

The CIAs mostly practice two rice croppings (wet and dry seasons) in a year. In Quilo-Quilo, some farmers plant corn and/or vegetables as second crop during dry season. Farmers in San Lorenzo also plant corn as second crop, particularly when they anticipate that water supply may not be adequate to support a second rice crop (dry season).

There are two cropping seasons every year in all locations (Figure 1). Most farmers start their first season (wet season) in June or July and ends in September or October, particularly in Quilo-Quilo South, Callejon-Del Valle and Tubig Biyaya. However, the second cropping season (dry season) varies by location. The second cropping season (dry season) in Quilo-Quilo South starts in October and ends in January, for Callejon-Del Valle and Tubig Biyaya starts in November or December and ends in March or April. Meanwhile, the first season in the cropping calendar in Bancuro is usually ahead by 1 month, starting in May and ending in August, so their second season is also ahead, starting in September and ending in December. On the other hand, the first season in San Lorenzo is usually late by 2 months, starting in September and ending in March, while their second season starts in April-May until September. The cropping season in San Lorenzo is different from the other CIAs because their dry season starts in September rather than May.

Figure 1. Rice cropping calendar of the study Communal Irrigator's Associations (CIA).

CIA	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Bancuro					🟪	🟪	🟪	🟪				
									🟦	🟦	🟦	🟦
Quilo-Quilo South						▨	▨	▨	▨	▨		
	🟦									🟦	🟦	🟦
San Lorenzo	▨	▨	▨						▨	▨	▨	▨
			🟦	🟦	🟦	🟦	🟦	🟦	🟦			
Callejon-Del Valle						▨	▨	▨	▨	▨		
	🟦	🟦	🟦	🟦							🟦	🟦
Tubig Biyaya						▨	▨	▨	▨	▨		
	🟦	🟦	🟦	🟦							🟦	🟦

There is an existing irrigation schedule in all the CIAs. The irrigation schedule is mostly fixed, except in Tubig Biyaya wherein the water distribution is rotational (Table 3). After 1 hour and 45 minutes (enough time to irrigate 1 ha of land), irrigation canals are closed in order to give chance for other areas to be irrigated. Regular cleaning of canals is also being done by the organizations, which involves removal of grass, trash or wastes that could clog the irrigation canals. Aside from cleaning canal, the Tubig Biyaya CIA also conducts desiltation activity twice a year. This is a necessary practice for this CIA which experience higher degree of siltation due to severe deforestation in their watershed areas.

Table 3. Water scheduling and maintenance and operation of the Communal Irrigation System (CIS) covered by the project.

Particular	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Water scheduling	▪ Fixed irrigation schedule	▪ Fixed irrigation schedule	▪ Fixed irrigation schedule	▪ Fixed irrigation schedule	▪ Rotation (1 ha = 1 hr & 45 mins)
System's operation and maintenance	▪ Cleaning canals	▪ Cleaning canals	▪ Cleaning canals	▪ Cleaning canals	▪ Dredging (2x a year) ▪ Cleaning canals

3.3 Vulnerability and Capability of Partner Communal Irrigator's Associations (CIAs)

Assessment of the current situation of the CIS and CIA provides answers to the question – 'where are we now?' It involves an examination of the IA's profile and the IS conditions and further scrutiny of its vulnerable aspects that constrain the performance of the IS and achievement of its goals. Vulnerability assessment is grounded on a thorough understanding of various resource endowments of the IS and IAs, i.e. including local hydrology, historical operating conditions, and standard operational practices. The main resource areas affecting vulnerability can be categorized into natural resource, technical and management aspects, human capital, economic capacity, and policy and institutional capacity of the IA.

3.3.1 Natural Capital

Natural capital, i.e. environmental aspects, includes climate conditions observed for the last 10-20 years, soil condition and properties, water sources, pests and diseases, and farm topography. Exposure to climate hazards increases vulnerability of the farm. Soil acidity affects crop yield and soil texture is related to water percolation. Moreover, as the distance of the farms from the water source becomes longer, water loss during the conveyance increases.

The CIS are usually run-off-the-river type dams, thus water supply is highly affected by rainfall patterns. According to San Lorenzo, Quilo-Quilo South and Tubig Biyaya CIAs, water level in the rivers that supply their irrigation water was low during dry season (January to April), such that many downstream farms could no longer be irrigated. Quilo-Quilo South observed lesser rainfall and longer dry season. No major climatic changes were observed in the case of Callejon-Del Valle.

In the recent years, heavier rainfall was observed by the Bancuro, San Lorenzo and Tubig Biyaya CIAs members. San Lorenzo MPC members observed more intense typhoons and severe flooding (Table 4).However, all CIAs observed greater climate variability in the sense that rainfall pattern sometimes do not coincide with their traditional cropping calendar. Early onset of the rainy season (May) is preferred by farmers because they can easily adjust their planting calendar and harvest their rice crops before the typhoon season which usually comes during the months of September to October. On the other hand, delayed onset of the rainy season exposes the first season crop to the risks caused by typhoons and flooding during the height of typhoon season. It also exposes the second (dry) season crop to severe water insufficiency which could greatly damage the crops. When the onset of the rainy season is delayed, many farmers can no longer plant their second crop (dry season) which extends up to the dry months of the year.

Given the resource endowments in these localities, it is possible to explore the use of STWs and SFRs as additional sources of water supply. Members also claimed that most of their farms are flat with few rolling areas. For instance, Quilo-Quilo South has about 20 ha of rolling lands. Flat lands are easier to irrigate than rolling or steep areas. In an upland area, percolation loss is high because unlike in lowland area, it does not have a hardpan which contributes to slower percolation of water. In adopting alternate wetting and drying water management technique, determining the number of observation well to be installed will depend on the level of the field. Uniform level of field would require only one observation well. The differences in the level of the field, the more number of observation wells that needs to be installed i.e. depending on the number of partitions in the field with different heights.

All IAs claimed that most of their soils are clayey (Table 4). Bancuro and San Lorenzo members mentioned that it is actually an advantage for them since water will not easily percolate. On the other hand, Quilo-Quilo South and Tubig Biyaya members observed that it has negative effects especially during rainy season, wherein planted rice tend to lodge if the soil is too clayey. Most of the IAs lands have no soil analysis or do not know the result of the analysis. Hence, farmers are not aware of the appropriate nutrients or fertilizer combinations that should be applied. Instead, farmers apply complete (14-14-14) fertilizer and urea (46-0-0) at the rate, timing and method they used to do.

Pests and diseases that attack farmers' rice crop and are common for dry and wet seasons. These include: rats, birds, golden snail, black bug, cat worm, weeds, cricket, stem borer, and bacterial leaf blight. All CIAs had also stated that they commonly used pesticides to address the problem, otherwise, 70 percent of yield will be lost due to pests and diseases.

Table 4. Natural attributes of Communal Irrigator's Association (CIA) covered by the project.

Particular	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Observed climatic changes during the last 20-30 years	▪ Heavier rainfall ▪ Climate variability ▪ Delayed or earlier onset of rainy season based on established cropping calendar	▪ Lower rainfall ▪ Climate variability ▪ Delayed or earlier onset of rainy season based on established cropping calendar ▪ Longer dry season	▪ Heavier rainfall ▪ Climate variability ▪ Delayed or earlier onset of rainy season based on established cropping calendar ▪ More intense typhoons ▪ Heavier flooding than before	▪ No changes in rainfall ▪ Climate variability ▪ Delayed or earlier onset of rainy season based on established cropping calendar	▪ Heavier rainfall ▪ Climate variability ▪ Delayed or earlier onset of rainy season based on established cropping calendar ▪ Shorter dry season
Soil type/condition	▪75% clayey soil ▪25% sandy soil	▪ Generally clayey	▪ Mostly clayey ▪ Soil analysis had shown that most of soils are acidic and deficient nitrogen	▪ Generally clayey ▪ Small portion is sandy	▪ Generally clayey
Water source	▪ River	▪ River	▪ River	▪ River	▪ River
Water supply	▪ Sufficient for both wet and dry seasons	▪ Not sufficient to supply the entire service area during dry season	▪ Not sufficient to supply the entire service area during dry season	▪ Not sufficient to supply the entire service area during dry season	▪ Not sufficient to supply the entire service area during dry season
Other possible sources	▪ Shallow tube-well ▪ Small farm reservoir	▪ Shallow tube-well ▪ Small farm reservoir	▪ Shallow tube-well	▪ Shallow tube-well ▪ Small farm reservoir	▪ Shallow tube-well ▪ Small farm reservoir
Pests and disease	▪ Rats, black bug, birds, and golden	▪ Weeds, golden snail, cricket, black	▪ Golden snail, rats, and birds	▪ Black bug and golden snail ▪ Observed in	▪ Stem borer, black bug, rats, golden

	snail ▪ Observed in both dry and wet seasons	bug, stem borer, and leaf blight ▪ More pests are observed during wet season	▪ Observed in both dry and wet seasons	both dry and wet seasons	snail, and cat worm ▪ Observed in both dry and wet seasons
Farm topography	▪ Generally flat	▪ Generally flat	▪ Generally flat	▪ Generally flat	▪ Generally flat

3.3.2 Physical Capital

Physical capital includes indicators such as age of the IS, condition of the dam or headgate, drainage systems, and canal structures and condition. The older the IS, the more vulnerable it is. Drainage problem also occurs when the drainage system is old or clogged, or if there is no drainage system at all. Poorly-maintained canals increase water conveyance losses. Farmers tend to use excessive water due to low efficiency of irrigation and drainage networks.

The San Lorenzo MPC already had its irrigation system since 1950. It is the oldest among five irrigation structures. The IS managed by the Tubig Biyaya IA was constructed in 1960, while the Callejon-Del Valle's IS was built in 1992. The construction of the irrigation in Quilo-Quilo South was started in 1990, but became fully operational only in 2002. The latest was the irrigation handled by Bancuro Communal IA which was constructed in 2008.

The CIS, being built many years ago, have undergone rehabilitations. Bancuro IA members stated that they conduct rehabilitation almost every year, while Quilo-Quilo South, San Lorenzo and Tubig Biyaya claimed that their dam/head gate is already in need major of repairs. The construction and rehabilitation cost of the IS in Quilo-Quilo South was PhP 23 million, while the IS in Callejon and Del Valle was PhP5 million. The Bancuro Communal CIA had rehabilitation in 2009 costing PhP 4.3 million, and PhP 5 Million in 2011 (Table 5). Callejon-Del Valle was able to maintain the good condition of their dam/head gate.

Tubig Biyaya's irrigation system was constructed more than 30 years ago, while Bancuro Communal and Callejon-Del Valle's irrigation system was constructed less than 10 years ago. For Quilo-Quilo South and San Lorenzo, their irrigation systems were built 10-20 years ago.

All irrigation systems use lateral canals. The IS in San Lorenzo has the most number of canals (8 canals) while Bancuro has the least (1 canal) . Meanwhile, Callejon-Del Valle and Tubig Biyaya have two canals each and Quilo-Quilo South has five canals. The longest main canal observed in Quilo-Quilo South with 7 km, while the shortest is in Bancuro with 1 km.

Table 5. Physical features of the communal irrigation systems.

Particular	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Year constructed	2008	1990	1950	1992	1960
Initial cost of	3,799,279.66	21,613,685.51	Don't know	4,032,326.83	691,211.84

construction (PhP)					
Rehabilitation cost (PhP)	9M	1.67 M	12 M	6.6 M	2.3M
Number of lateral canal	1	5	8	2	2
Main canal length (km)	1	7	3	2	2

San Lorenzo CIA members experienced water distribution problems due to clogged canals, which were old and not cemented but lined with adobe instead. The other IAs did not experience water distribution conflict such problem because their canals were made of concrete and well- maintained (Table 6).

Table 6. Other physical conditions of communal irrigation system

Particular	**Bancuro Communal Irrigators' Association**	**Quilo-Quilo South Communal Irrigators' Association**	**San Lorenzo Multi-Purpose Cooperative**	**Callejon-Del Valle Communal Irrigators' Association**	**Tubig Biyaya Communal Irrigators' Association**
Dam/head gate condition	▪ Well-maintained	▪ Need major repairs ▪ no steel gate yet and replaced every two years	▪ Need major repairs	▪Well-maintained	▪ Need major repairs
Drainage system condition	▪ No problems caused by poor drainage system ▪ One water tender per sector manages the flow of irrigation water in the sector	▪ No problems caused by poor drainage system	▪ Poor drainage systems due to clogged canals and oldness	▪ No problems caused by poor drainage system	▪ No problems caused by poor drainage system
Canal structures	▪ About 1km of lateral canal is not yet concrete	▪ All lateral canals are not concrete	▪ Main canals are concrete ▪ Lateral canals are constructed with adobe lining and currently need repairs	▪ Only 35% of lateral canals is concrete	▪ About 50% of lateral canals is not concrete
Canal	▪ Not well	▪ Well-	▪ Need major	▪ Well-	▪ Well-

condition	maintained	maintained	repairs	maintained	maintained

3.3.3 Human and Social Capital

The success of an irrigation system depends largely on the active participation and cooperation of individual farmers. The match of social capital with physical capital engineering works affects the operation and management of the IS. Institutional support system also helps reduce vulnerability.

Human and social capital indicators include education and training of IA members; participation of members in meetings and IA activities; and extent of support from outside sources, e.g., LGU, NIA.

Except for Tubig Biyaya, IA members stated that they have insufficient trainings. In addition, Bancuro, Quilo-Quilo South, Callejon-Del Valle and San Lorenzo IA members have insufficient knowledge on climate change and its impacts. Officers stated that this is because most of those who attend trainings and seminars are the officers while other members ignore these activities. Only Tubig Biyaya stated that their members have sufficient trainings and knowledge on climate change and its impacts (Table 7).

There is also insufficient participation of members on meetings except for Tubig Biyaya IA. In most cases, members who attend meetings relay to those who did not attend what has been discussed and agreed. Thus, whenever new policies were approved, some members did not completely understand the policy and its rationale. In addition, they cannot do anything about the new policy since they did not attend the meeting where they can discuss their position regarding the policy. In addition, there are also members of these IAs who have already relocated to other places. Although there is a high number of attendees in Tubig Biyaya's meetings, most of them are only representatives of the members, not the actual members themselves.

Participation of members in operation and maintenance activities is sufficient in the case of Quilo-Quilo South, Callejon-Del Valle and Tubig Biyaya. In the case of cleaning canals, some members of the IAs just hire people who can do the job for them or sometimes, they hire co-members. In the case of support from other institutions, they stated that the extent of support from the local government is insufficient while support from NIA is sufficient due to the presence of Institutional Development Officers (IDOs) who regularly monitor the IAs and perform information dissemination of new policies and other news from NIA (Table 7).

Table 7. Human capital endowment of the Irrigators' Associations.

Item	**Bancuro Communal Irrigators' Association**	**Quilo-Quilo South Communal Irrigators' Association**	**San Lorenzo Multi-Purpose Cooperative**	**Callejon-Del Valle Communal Irrigators' Association**	**Tubig Biyaya Communal Irrigators' Association**
Number of members	35	100	97	105	79
Knowledge level					

- Climate change and its impacts - AWD technology - CIA policies	Limited Very limited Limited	Limited Very limited	Limited Very limited	Limited Very limited	Sufficient Very limited
Members attendance in seminars/trainings	Low	Low	Low	Low	Medium
Participation of members in Operation &Management activities	- Limited; some members hire workers to clean the canal for them	- Many - A minimum of 20 members participate in collective actions such as cleaning canals - Some do not want to participate - cleaning is done twice in a cropping season	- Limited - Some members hire people to clean canals	- Very limited - Members took part in cleaning canals as well as cleaning the dam	- Many - Twice a year cleaning of canals and dam and frequent during dry season
Extent of Local Government Unit's support	- High - Often provides financial support for system Operation & Management	- Very low - LGU only provides assistance during disaster and calamities	- Low - LGU only provides assistance during disaster and calamities	- Low	- Low
Extent of National Irrigation Administration support	High	High	High	High	High

3.3.4. Institutional and policy capability of CIAs

A well- organized IA adopts a structure of relationships among members that enable them to adopt values. The adoption of by-laws or rules-in-use indicates the capacity of the IA to manage the system. Water sharing agreements increase IAs' robustness to crisis events such as water scarcity.

There are policies that are being observed in each of the IAs regarding water sharing arrangement, irrigation scheduling and meetings. In all of the organizations, water sharing policies are clear but are sometimes not strictly implemented. Assessment also revealed that there is a certain percentage of members who were not observing the irrigation schedule. About 50% of the members of Callejon-Del Valle IA did not observe the schedule while 10% of the members in San Lorenzo MPC and Bancuro Communal IA did not observe this. In order to improve the members' compliance to the water policy, the San Lorenzo MPC hanged a banner which indicates their irrigation schedule. Only 5% of the members in

Quilo-Quilo South IA did not observe the irrigation schedule while the Tubig Biyaya IA did not experience any problem among their members.

In terms of water use, Bancuro and San Lorenzo IA members were used to irrigating their farm with excess amount of water. Thus, even if there were agreements on water use, the members do not comply. On the other hand, only about five percent of Quilo-Quilo South IA members were using excess amount of irrigation water while only those near the dam in Callejon-Del Valle were able to use excess amount of irrigation water. Most of the area in Callejon del Valle lack irrigation water. Unlike the aforementioned IAs, the Tubig Biyaya IA members complied with their agreement on irrigation water use since they impose fines for those who will use excessive amounts of irrigation water.

General assembly and meetings are also being done in these organizations, except that the San Lorenzo MPC did not have a regular general assembly, instead their officers hold quarterly meetings. General assembly for the four IAs are held annually but BOD meetings, which is held monthly, is done by two IAs only (Quilo-Quilo South and Tubig Biyaya IAs) while the Callejon-Del Valle IA does not hold BOD meetings. Special meetings are also held by Tubig Biyaya and Bancuro Communal IAs to solve problems that arise while the Quilo-Quilo South IA holds quarterly committee meetings.

Table 8. Policy capacity of the CIAs

Item	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Proportion of members who regularly attend meetings (%)	30	60	▪ No regular GA since the organization is currently a cooperative ▪ Only few of the officers attended the regular officer's meeting*	50	85
Proportion of members not observing irrigation scheduling	Less than 10%	About 5%	About 10%; members who own large farms oftentimes do not follow irrigation scheduling	About 50%	None
Water use	Most members used more amount of irrigation water than what was agreed	About 5% of members used excess amount of irrigation water because they were used to that practice	▪ Members use very high amount of irrigation water which sometimes caused disagreements among members	▪ Most areas lack irrigation water ▪ Only farms near the dam have enough supply and sometimes excess irrigation water	▪ Always enough ▪ Fine is imposed for those who will violate the agreement on water use
Proportion of members not	Only 3 members do	10% are promising that	▪ All are paying but lower than the	High	None

paying irrigation fee	not pay on time	they will pay but have not done so	amount they should pay ▪ sometimes harvested crop was also accepted as payment		
Meetings	▪ Yearly general assembly ▪ Special meetings whenever problems arise	▪ Yearly general assembly ▪ Monthly meetings of BODs ▪ Quarterly meetings of committees	▪ No regular general assembly ▪ Quarterly meetings of officers	▪ Yearly general assembly	▪ Yearly general assembly ▪ Monthly board meeting ▪ Special meetings are conducted when there are problems that need immediate solution

3.3.5 Economic capacity of CIA

Indicators of economic capacity of an IA may include ISF collection efficiency, size of farm lands served, land ownership, cropping pattern; and crop productivity. Lower collection efficiency will affect operation and maintenance of the IS. A high level of leasehold arrangements may affect irrigation service fee collection when landowner and lessee both disclaim responsibility for the payment. Land fragmentation and may also result in the non-payment of ISF.

Most farmers operate one hectare of land, with a range of land size from half hectare to as big as seven hectares (Table 9). The range per location, however, varies. Members of Bancuro, Callejon-Del Valle and Tubig Biyaya IAs operate with the smallest land size of 0.5 hectares to largest size of 4.0 ha, 7.0 ha, and 5.0 ha respectively. The farmers' land size in Quilo-Quilo South ranges from less than a hectare to 2.0 ha and land size in San Lorenzo range from 0.75 ha to 2.0 ha.

The land cultivated was generally owned by owner operators in Bancuro CIA and Quilo-Quilo South IA, where 75% and 77% are owner operators. But for the other IAs, most of them are tenants where only 30% are owner operators in San Lorenzo MPC, 20% in Callejon-Del Valle and 13% in Tubig Biyaya IA.

Irrigation service fee (ISF) payment schemes for all IAs are similar, such that they pay a set amount per hectare every year. The Quilo-Quilo South IA however has the highest ISF at PhP1200/ha/season or PhP2400/ha/year. This is followed by the Tubig Biyaya IA where members pay PhP1800/ha/year which is used for the rehabilitation and additional PhP200/ha/season (equivalent to PhP400/ha/year) for water management. The Bancuro Communal IA and the Callejon-Del Valle IA members pay an amount of PhP1500 and PhP1300 per hectare per year, respectively. On the other hand, the San Lorenzo MPC collects 3 cavans of rice/ha/year (equivalent to PhP1400) instead of cash.

Farm yield in the areas range from around 3 cavans/ha (Callejon del Valle), to 4 cavans/ha in San Lorenzo, to 6 cavans/ha for the other IAs. The low yield consequently affects farmers' payment of ISF. Collection efficiency was high in Bancuro Communal and Tubig Biyaya IAs at 100%. San Lorenzo MPC had 60% collection efficiency while Quilo-Quilo South had 70% efficiency. Tubig Biyaya IA did not experience any problem in collection and Bancuro Communal IA only experienced having three members who are not paying on time. In contrast, there is a very low collection efficiency in Callejon-Del Valle IA because many members are not paying their irrigation fee. San Lorenzo MPC also had problems with members who are not paying the right amount.

Table 9. Economic capacity of the Irrigators' Associations

Item	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Average farm size (ha)	1	1	1	1	1
Farm size range (ha)	0.5 - 4	0.5 - 2	0.75 - 2	0.5 - 7	0.5 - 5
Cropping pattern	Flexible	Flexible	Flexible	Cannot adjust easily	Flexible
Crop productivity	Increasing in the last 10 years	No changes	No changes	No changes	Increasing due to assistances and support from different institutions and organizations
Average rice yield (tones/ha)	5 -6	5 - 6	4.2-4.5	3 - 3.5	5 - 6
Irrigation Service Fee per member	PhP 1500/ hectare/ year	PhP1200/ hectare/ cropping	3 cavans/ hectare or PhP 1400/ year	PhP 1300/hectare/ year	PhP 400/ha/year (P1,200/ha/yr – if loans from NIA are not yet paid)
Collection efficiency (%)	▪ 100	▪ 75	▪ 60 ▪ zero during calamities	▪ Very low	▪ 100
Other sources of funds	▪ DA ▪ LGU	none	▪ Congress (CDF) ▪ LGU	▪ DA	▪ Private company ▪ LGU

The cropping patterns of farmers are flexible except in Callejon-Del Valle where they cannot easily adjust planting rice to other months. This may be due to their problems in irrigation water that was mentioned in the section on CIS management and technical aspect.

Unawareness of some policies also affects the IAs economic capacity. For instance, they are not aware that the cost of projects (e.g., rehabilitation) that were implemented by NIA requires repayment by the IAs/farmers. There were also cases that the IAs assumed that request for funding from some politicians were grant , only to find out from NIA staff that the politicians only act as intermediary between NIA and the CIA. The money spent for irrigation projects still come from the NIA funds and not from the politicians, and therefore IAs have to pay this back to NIA.

Results of the self-assessment by the CIA members of their vulnerability and their capability show that Tubig Biyaya CIA was the most successful. It has an average score of 1.42 while Callejon-Del Valle CIA, which got an average score of 2.91 was the least stable CIA of the five CIAs studied. Tubig Biyaya obtained the highest score in terms of human and social capital, institutional and policy capability, and economic capacity but ranked second only in terms of physical and natural capital largely because of the heavy dam siltation and low water storage capacity. On the other hand, Callejon-Del Valle ranked highest in terms of the physical attributes of their irrigation system but low in other aspects particularly in institutional and policy capability as shown by their weak capability to implement their rules and regulations. The strengths of Bancuro CIA were in terms of their natural capital and economic capacity but are relatively short of the desired human capital endowment. They express their desire for greater knowledge in terms of alternative water management and other agricultural technologies. The same sentiments were expressed by Quilo-Quilo South CIA members who also ranked themselves relatively low on the human capital aspect because only the officers usually attend seminars and trainings and are exposed to new knowledge. San Lorenzo MPCI received the lowest score on the physical capital component because their system needs major repair and their canals are not yet concrete. Their economic capacity, however, was rated high because of their high collection efficiency.

Table 10. Self-assessment of CIA members

Indicator	Bancuro CIA	Quilo-Quilo South CIA	San Lorenzo MPC	Callejon-Del Valle CIA	Tubig Biyaya CIA
Natural capital	1.50	1.88	2.00	2.13	1.63
Physical capital	2.25	2.00	2.75	1.50	1.75
Human and social capital	2.43	2.29	2.57	2.71	1.29
Institutional and policy capability	1.50	1.50	2.00	3.00	1.00
Economic capacity	1.00	1.67	1.67	2.33	1.00
Average	1.83	1.96	2.25	2.91	1.42

1-Least vulnerable 2 – Moderately vulnerable 3 – Most vulnerable

3.4 Rice production and alternative water management strategies

This section presents a summary of the lectures delivered during the awareness raising and capacity building seminars for the CIA members and the experiences of the guest CIA regarding water management and fund sourcing that were shared with study CIAs.

The management plan designed by farmers incorporates strategies that they could possibly adopt to address current problems. The lectures conducted for the IAs covered topics on a) rice production and water use; b) alternative wetting and drying and aerobic rice; c) operation and maintenance of communal irrigation system (CIS); d) effective water management under different environmental conditions; and e) assessing the feasibility of alternative water sources.

Below is a summary of these lectures.

3.4.1. Water Use in Lowland Rice-Based Production System

Ponded water, either coming from rainfall or irrigation, has to be maintained for at least 80% of the irrigated lowland rice crop's duration to attain target yields. Water deficit or drought usually affects rice, but with varying degree depending on its occurrence during crop growth and development, which is reflected on the following yield-determining components: such as number of panicles, number of spikelets per panicle, percent filled spikelets and grain weight. If drought occurs during tillering stage, the number of tillers and leaf area could be significantly affected. Rice crop may recover if rewatered at an ample time to resume tillering before the onset of panicle initiation. Severe water stress may cause significant reductions in number of spikelets or failure of the panicles to come out (panicle exertion) of the stalk during reproductive stage, particularly within the 2 weeks before flowering. Drought stress during flowering, significantly reduce the number of filled spikelets due to the disruption of pollination and fertilization process. If drought occur after fertilization, some spikelets may not be filled up, particularly those with weaker source-pulling capacity. Hence, flowering stage and few days after flowering are most sensitive to drought stress. During grain filling, grain weight development is most sensitive to water stress during the first 15 days which covers the milk and soft dough stages. Beyond 15 days after flowering, small gain in weight takes place, particularly under tropical condition.

The Philippines has four climatic types as proposed by Fr. Corona, based on the distribution of rainfall within a year. A month is considered a dry month when cumulative monthly rainfall is less than 50 mm. In a lowland rice-based production system, wet season rice crop (July-October) can be classified as an irrigated, when rainfall is inadequate to support the crop water requirement within the season and supplementary irrigation is applied. For dry season rice crop (December-March), full or supplemental irrigation is needed, depending on the amount of rainfall during the season. Areas with distinct dry and wet seasons (Type I) generally require irrigation during the dry season. Areas with short dry periods (Types III and IV) or with well-distributed rainfall throughout the year (Type II) may need supplemental irrigation when rainfall is limiting. Total or supplemental irrigation is practiced during dry or wet seasons particularly during the years of El Nino occurrence, while lessen during the La Nina years.

Cropping intensity and crop sequences are highly dependent on the availability of water to support one or more rice crops within a year. When water, whether from rainfall or irrigation, is limiting during dry season, farmers opt to replace the supposedly dry season lowland rice crop with upland crop that requires lower amount of water compared with lowland rice. Under conditions of extreme inadequacy or unavailability of water during dry season, farmer may decide not to plant any crop and wait for the next wet season. Thus, varying cropping sequences are practiced at site-specific level, depending on the available amount of water for crop use during the growing period. Some of the crop sequences being practiced in rice-based areas of the country are: 1) triple rice cropping system (rice-rice-rice); 2) double rice cropping system (rice-rice); 3) rice-upland crop; and 4) rice-fallow.

There are three situations wherein possible interventions of varying degrees can be done in a specific irrigated lowland rice area, namely: 1) areas with existing irrigation facilities and adequate water source for wet and dry seasons; 2) areas without or inadequate irrigation facilities, while potential source of water is available; and 3) areas without or inadequate irrigation facilities and potential source of water to augment the existing water use is not available. The possible interventions under the above-listed scenarios could be one or combinations of the following: 1) improvement of the efficiency of irrigation; 2) further tapping of the water source; and 3) use of water-saving cultural practices. All of which, will result to the expansion of the service area of an irrigation facility per cropping due to irrigation water saved, and increase in cropping index from 2 to 3, with 3rd crop as rice or upland crop, due to additional irrigation water and/or water saved per cropping. Adaptation of lowland rice production under water-limiting conditions may involve either one or combinations of the following practices: 1) fallow period or turn-around time between cropping; 2) straw/stubble and weed management before land preparation; 3) use of rice varieties, 4) crop establishment; 5) water management during crop growth period; and 6) selection of appropriate crop sequence or crop rotation.

The Water Balance of Lowland Rice

Lowland rice is flooded in nature, its water balance and water productivity are different from those of other cereals such as wheat and maize. Water input into the rice fields are needed to match the outflows by seepage, percolation, evaporation and transpiration.

Seepage is the lateral subsurface flow of water and percolation is the downflow of water below the root zone. Combine values of seepage and percolation vary from 1-5 mm/day in heavy clay soil to 20-30 mm/day in sandy and loamy soils. Evaporation occurs from the ponded water layers and transpiration is water loss from the leaves of the plants. Combined evapotranspiration rates of rice field are 4-5 mm/day in the wet season and 6-7 mm/day in the dry season, and it can be as high as 10-11 mm/day in the sub tropical region before the onset of the monsoon.

Total seasonal water input into the rice field (rainfall plus irrigation) varies from 400 mm in heavy clay soil with shallow groundwater tables to more than 2000 mm in sandy or loamy soils with deep groundwater tables. 1300-1500 mm is a typical value for irrigated rice in Asia. Outflow of water by seepage and percolation accounts for about 25-50% of all water inputs in heavy soil with shallow water tables of 20-25 cm depth; and 50-85% in coarse-textured soils in deep water tables of 150 cm depth or more (IRRI).

Irrigated lowland rice is transplanted or direct (wet) seeded into puddled lowland fields. Land preparation consists of soaking, plowing, and puddling. Puddling is done not only to control weeds, but also to increase water retention, reduce soil permeability, and ease field leveling and transplanting (De Datta 1981). Soaking, a one-time operation, requires water to bring topsoil to saturation and to create a ponded layer. After land preparation, there is an "idle period" until transplanting or direct seeding takes place.

The growth period of rice runs from establishment to harvest. During the crop growth, fields are typically flooded with 5-10 cm of water. Under flooded conditions, water is required to match several outflow processes. Because of standing water, hydrostatic pressure continuously "pushes" water downward through the puddled layer, thus percolation and seepage takes place. Water is released into the air by evaporation from the ponded water layer, and transpiration by the crop. However, during land preparation and idle period, only evaporation takes place, whereas, during crop growth, both evaporation and transpiration occurs.

Of all outflows of water from the rice field, only transpiration is “productive” water use, as it leads to crop growth and yield formation. It is essential to plant growth because it provides cooling and is driving process for water flow in plants that carries nutrients from the roots to the shoot. Unproductive water losses were causes by seepage and percolation.

Growth Stages of Rice Plant

Rice is germinated at 2-3 days depending on varieties. Seedling can be produce in 3-12 days in the field or in other designated areas specially those that were to be transplanted, or with the more developed tillers up to 17.5 days. Vegetative growth stage is 17-33 days, but stem development can also be observed during 25-33 days. From 33-50 days panicle initiation and booting could be seen, and so with the reproductive stage at 37-74 days wherein heading is developed within 52-58 days. Flowering is observed at 68-74 days, milk developed by the grain between 75-85 days. At 86- 105 days ripening of the grain is now observed and totally matured grains can be observe 102-120 days.

3.4.2 Water Management Strategies to Reduce Water Input

Bouman and Tuong 2001, stated that reducing seepage and percolation flows through reduced hydrostatic pressure can be achieved by water management. Instead of keeping the rice field into continuously flooded with 5-10 cm of water, the floodwater depth can be decreased, the soil can be kept around saturation (SSC), or alternative wetting and drying (AWD). Under these management practice, the hydrology of the soil changes from anaerobic under flooded and SSC regimes to alternately anaerobic and aerobic under AWD. Ultimately, rice could be grown under completely aerobic conditions and the SP eliminated.

Alternative water saving technologies

Depending on the situation at the system level, the technologies for water savings shall include but not limited to the following:

Dry Tillage – Dry tillage is recommended in order to save about 30% of the total water requirement in rice production. The water traditionally require for puddling the soil will be saved and therefore be used in directly irrigating the rice crop during emergence. Usually traditional practice of the old farmers is to prepare the fields dry specially those that are situated in the rainfed lowland. The idea is to expose the grasses to the heat of the sunlight in order for the grasses to wilt and dried up, thus, eradicating the weeds faster.

Dry Seeding – dry seeding technique should be adopted in combination with dry tillage. Seeds will be sown and broadcasted, covered with soil and flash-irrigated, if necessary, to supply the moisture for germination and initial crop establishment. Appropriate weed control technologies should be practiced in coordination with the above indicated practice. Chemicals for weed control were also sprayed in time at dry land conditions for speedy weed elimination. Seeds to be sown were usually those that can emerge even with the moisture that developed in the soil during night time. Among the examples of upland varieties were taken from Philippine seedboard (PSB)/NSIC Rice Varieties listed from Philrice: PSB RC1 (Makiling) an IRRI variety; PSB RC3 (Ginilingang Puti) a traditonal variety; PSB RC5 (Arayat) IRRI variety; PSB RC7 (Banahaw) Philrice variety; NSIC RC9 (Apo) IRRI variety; and NSIC RC11 (Canlaon) by Philrice.

Alternate Wetting and Drying (AWD) or Controlled Irrigation (CI) Alternate Wetting and Drying (AWD) or Controlled Irrigation (CI), is a water saving technology that lowland (paddy) rice farmers can apply to reduce their water use in irrigated fields. In AWD, irrigation water is applied to flood the field a certain number of days after the disappearance of ponded water. Hence, the field is alternately flooded and non-flooded (allowed to be dried). The number of days of non-flooded soil in AWD between irrigations can vary from 1 day too more than 10 days.

A practical way to implement AWD is to monitor the depth of ponded water on the fields using a "field tube". After irrigation, the depth of ponded water will gradually decrease. When the water in the field has dropped to 15 cm below the surface level of the soil, irrigation should be applied to re-flood the field with 5 cm of ponded water. From one (1) week before flowering to one (1) week after flowering, ponded water can be maintain or kept at 5 cm depth. After flowering, during grain filling and ripening, water level can be allowed to drop again to 15 cm below the surface of the soil before re- irrigation.

AWD can be started a few days after transplanting (or with 10 cm tall crop in direct seeding). When the indication of many weeds is noted, AWD can be postponed for 2-3 weeks until weeds have been suppressed by the ponded water. Local fertilizer recommendations as for flooded rice can be used. Apply Nitrogen fertilizer preferably on the dry soil just before irrigation.

Safe AWD

The threshold of 15 cm water depth below the soil surface before re-irrigation is called "Safe AWD" as this will not cause any yield decline. In safe AWD, water savings are in the order of 15-30%. After creating confidence that the safe AWD does not reduce yield, farmers may experiment by lowering the threshold level for irrigation to 20, 25, 30 cm depth 0r even deeper. Lowering the threshold level for irrigation will increase the water savings, but some yield penalty may occur. Such a yield penalty may be acceptable when the price of water is high or when water is very scarce.

3.4.3 Operation and Maintenance of Communal Irrigation Systems

Communal Irrigation Systems (CIS) are small-scale schemes, defined as less than 1000 hectares but typically averaging about 100 hectares. They are usually run-off-the-river type dams designed and constructed by the National Irrigation Administration (NIA) with the participation of farmer-beneficiaries through the Irrigator's Associations (IA). The operation and maintenance of CIS is turned over to IAs upon project completion subject to a cost recovery arrangement. The repayment scheme is pre-arranged and acceptable to both NIA and the IA.

There are some difficulties in managing irrigation systems that contribute to low water use efficiency and poor performance of irrigation systems. The objectives of irrigation systems were defined from three different perspectives: the farmers, the system operator, and the government. The farmers want to achieve the maximum possible yields by having immediate access to irrigation water, whenever they need it, at a sufficient rate, and for as long as they want. This is often in conflict with the government objective which is to spread irrigation benefits over a large group of people to increase crop or food production, create employment and reduce rural poverty. But due to high construction cost, limited budget and supply, the irrigated area is less and total freedom in water utilization suffers. It is the system operators' objectives to manage the scheme in a way that is acceptable to all parties through equitable water allocation, efficient distribution and formulating simple operating procedures. A service agreement is needed to reconcile these objectives and to create a situation that is acceptable to all. It should be amenable to adjustments and improvement after every irrigation season.

There are some methods of operating a small-sized irrigation schemes and there are working principles involved to make the system function, and keep it functioning. These include the basic techniques of water distribution, such as supply at will or 'on demand,' time sharing or 'rotation' and flow sharing or 'partition.' Proper irrigation planning and scheduling were discussed based on the cropping pattern, taking into consideration the farmer's preference and the prevailing or expected weather pattern. Proper maintenance tasks for small-sized irrigation schemes were then discussed. These include routine maintenance, emergency works and system improvements.

3.4.4 Climate Forecast Application for Effective Water Management

Climate change is expected to intensify the many problems facing agriculture in our country. The dry seasons have become more prolonged and intense while the rainy seasons have brought widespread flooding and induced pest and diseases. Most vulnerable are rainfed areas and those relying on small rivers and streams for irrigation such as communal irrigation systems. An extreme climatologic event that poses a major threat to rice-based agriculture is the El Niño phenomenon. It is important to understand and be able to predict the effect of El Nino on rice production to be able to put in place effective coping mechanisms at the more vulnerable rural farming communities. Farmers and the Irrigators Association (IAs) managing small-scale irrigation systems often do not have the information or are informed too late about such extreme events to be able to respond in a favorable manner. A different water management procedure that is applicable during extraordinary drought should be put in place. The IAs should be made aware of early warning systems that would enhance their coping capacities and support timelier and better coordinated response to such climatic extremes. This paper presents the effects of El Niño on Philippine rainfall and rice production.

The effect of El Niño on Philippine rainfall is initially felt 3 to 5 months after the development of a warm episode in the tropical Pacific. Strong El Niño events have short but intense effect while weak-to-moderate events have longer but milder effect on Philippine rainfall. During the peak of strong events, more than 50% reduction of monthly rainfall is expected and about 29% lower than the average number of tropical cyclones.

The effect of El Niño on rice production depended on the strength and time of occurrence of the warm episode. During the dry season, strong, moderate and weak El Niño events reduced total rice production by about 22%, 6% and 0.3%, respectively. For the wet season, weak episodes increased rice production which may be attributed to less flood damages and higher level of incident solar radiation.

A projected El Niño-induced drought will affect agricultural water supply sources, in chronological order: rainfed areas; small streams and creeks; small run-off-the-river irrigation systems; small water impounding irrigation systems, small farm reservoirs or farm ponds; large rivers; large reservoirs; and finally, aquifers.

Enhancing the capability of farmers and water users group through early warning and response system scan help mitigate the impact of these extreme events. Given enough warning time, an effective water management procedure can be planned and adapted for the whole cropping.

3.4.5. Assessing the Feasibility of Alternative Water Supply Sources

During prolonged dry seasons and extraordinary droughts, Irrigators Associations (IAs) may supplement irrigation in communal irrigation systems using alternative water supply sources. Depending on the farm location, IAs may opt for shallow tube wells (STW) or low-lift pumps (LLP), small water impounding projects (SWIP), small farm reservoir (SFR) or any of the small-scale water harvesting techniques such as rain-interceptor ponds (RIP) dug-out ponds (DOP) and open ditches (OD). This paper presents the advantages, disadvantages, costs and requirements for each of these options to help IAs decide what to adapt for their respective areas.

STW are pipes installed in the ground for the purpose of bringing groundwater into the soil surface. They are usually set at a depth of less than 20m and extracts water from shallow aquifers using centrifugal pumps powered by single cylinder diesel or gas engines and electric motors. Aside from the presence of extensive shallow well areas in the Philippines, STWs are cost-effective with low investment cost from P5,000 to P30,000 per hectare. In some CIS where the dependable flow in the river cannot sustain the design command area or that the river surface is too deep to be raised by a weir, LLPs can be used to pump water to the farm. LLPs are cost-effective with low investment cost of from PhP 3000 to 8000 per ha.

A SWIP is an earth dam structure built across a narrow depression or valley to harvest and store rainfall and run-off for multiple uses. At less than 30-m height, SWIPs can service from 20 to 150 ha per project at an average investment cost of about PhP150,000/ha. A SFR, on the other hand, is a water impounding structure with maximum embankment height of 4-m and average pond area of 1,500 m^2. It serves limited areas no more than 2 hectares and is designed to become an integral part of individual rainfed farms with catchment area not exceeding 10 hectares. IAs can also use small scale water harvesting techniques that collect or trap rainfall and runoff on excavated ponds (DOP), canal systems (OD) and sloping lands (RIP or RID).

3.4.6 Alternative Resource Mobilization Strategies

Pinag-isang magsasaka ng Masiit CIA is a relatively bigger CIA and more experienced organization compared to the study CIAs. It has 188 members and the CIS serves a total of 484 hectares of rice land. The system can sufficiently irrigate its service area year round due to its abundant water supply which comes from several rivers and the lagoon of an industrial plant. Consequently, most of the farmers plant rice for two cropping while a few others plant three cropping per year.

Most of their members are aware of and are practicing the alternate wetting and drying even if water availability is not a serious problem for them. In addition, they use new rice varieties that are adaptable to varied climatic conditions such as those resistant to drought or submergence.

The CIA can be considered a mature organization in terms of its structures, policies and procedures. Members' participation and extent of cooperation in CIA activities are high although they also encounter some operational problems like non-compliance by some members with CIA rules such as water scheduling and ISF payment. Their experiences showed that there are various means of mobilizing resources and a number of government institutions that CIAs can tap for needed assistance.

Through the resourcefulness of the CIA leadership, they were able to access support from local politicians for rehabilitation of dam, DSWD's "Food for Work" project for system maintenance, LGU for post-harvest facilities (e.g. flat bed dryer) and the national government for irrigation system improvement. As a consequence, they were not indebted to the government and they were not subject to any cost recovery program.

As a form of advice, they asked the study CIAs to be diligent in following-up their requests for assistance. According to them, there are vast opportunities that can be tapped for assistance but they have to explore those and make proper representation, submit resolution and requests for support. More importantly, the CIA has to coordinate with their *barangay* and the Municipal Agriculturist Office (MAO). Strong cooperation is the key to a successful organization and improved well-being of members.

3.5 Water management and institutional development plan

A number of water management problems were identified by the partner CIAs during the vulnerability assessment. The system management problems were varied but there were institutional problems that affect water allocation and water use efficiency, which are common to all partner CIAs. The current strategies as well as other possible options to address the identified problems and potential sources of assistance were also discussed during the focus group discussion.

Irrigation management planning made use of the knowledge and lessons learned from the lectures conducted by agronomists, agricultural engineers, and other experts. These provided the various options and strategies which they could target for adoption, e.g., water utilization technology and method; post-rehabilitation management of the system such as the type of production process including crops and cropping patterns, methods of production, including irrigation methods and O&M; and the degree of participation by different actors or stakeholders in the process.

3.5.1 Bancuro CIA

One of the problems identified by the CIA members was water distribution conflict. Currently, Bancuro CIA assigned water tenders for each sector to monitor the irrigation water use by members. Most members also apply alternative water management technologies such as alternate wetting and drying, particularly during the dry season (Table 11).

To increase water supply and minimize conflicts, the officers also plan to install Shallow Tube Wells (STWs) and construct additional Small Water Impounding Facilities. Planting of alternative crops such as vegetables and white corn which have low water demand was also suggested as additional sources of livelihood by farmers during the dry season. Lack of financial and technical capability is among the constraints to the adoption of these alternative options. The CIA plans to tap other sources of assistance such as local government, NIA and DA. Other problems identified were damaged dam and incomplete construction of lateral canals particularly in sector four of the system. The CIA was able to obtain funds from their congressman for the repair of the damaged dam while construction of lateral canals in sector four has been started through the initiative of the landowners whose lands will benefit from this project.

Table 11. Summary of Bancuro CIA plan based on perceived problems and vulnerability assessment

Issues/Problems	Current strategy to address the problem	Other options that could be adopted	Constraints	Possible Sources of Support
Water distribution conflict	Assigned water tender	Install STW	Financial Resources	▪ NIA
Insufficient water supply	Water scheduling	Construct STW	Financial support, feasibility study , appropriate knowledge on other suitable crops	▪ LGU ▪ BSWM ▪ NIA
		Construct SWIP		
		Plant alternative crops such as vegetables and white corn		
		Educate members on alternative water management (e.g. AWD)		
Faulty dam construction	Modification or repair of dam		Technical assistance re appropriate design, financial support	▪ LGU Calamity fund ▪ Congressman
Service area not yet fully irrigated	Construction of earth canals	Build concrete canals	Financial Support	▪ Landowners who will benefit from canal construction ▪ Congressman

3.5.2 Callejon del Valle CIA

This CIA faced more serious social, institutional and technical problems (Table 12). According to the CIA officers, the CIS was poorly designed and the volume of water flow in the river was not enough to fully irrigate its target area. The dam is at the tail-end of the river which passes through two other communal irrigation systems upstream. Thus, the major problem that they identified was insufficient water supply. The water supply problem was aggravated by the irresponsible use of some members whose farms are located near the dam. These farmers were constantly flooding their farms despite CIA policy to regulate water use particularly during dry months.

To augment the water supply, the CIA opted to install shallow tube wells which were obtained on loan from NIA. However, based on previous experiences, this option may not be considered the best. Some landowners who installed STW in the past were not able to successfully draw water from the wells and had to give up this option. Furthermore, the high cost of fuel to operate the pump would mean higher cost of production for farmers.

The CIA also proposed the construction of a small water impounding facility near the dam to collect excess water that floods the rice fields during the rainy season. However, there are still looking for donors for the construction of such facility.

The other serious problems of the CIA were the low attendance in meetings and low ISF collection rate. This can be partly attributed to the fact that most CIA members were absentee land owners who do not reside within the village. Most of the actual cultivators were tenants who do not have security of tenure because they are often replaced by the landowner. As a consequence, both the absentee landowner and the tenant-cultivator have limited knowledge and compliance with CIA policies. The CIA plans to encourage compliance through strict enforcement of rules and regulations.

Table 12. Summary of Callejon del Valle CIA plan based on perceived problems and vulnerability assessment

Issue/Problem	Current Strategy to Address the Problem	Other Options that Could be Adopted	Constraints	Possible Sources of Support
Insufficient water supply	Install Shallow Tube Wells	Educate members on alternative water management (e.g. AWD)	· Financial resources · Design	Propose to the Department of Agriculture
Low attendance in meetings and low ISF collection	Strengthen Information, Education and Communication activities	· Revise membership qualification · Encourage actual operators become members instead of absentee landowners as members · Enhance appreciation of IA members of their responsibilities	Stakeholders' participation	· NIA
Poor compliance with cost recovery program	Efforts to intensify Irrigation Service Fee collection	· Look for grants to improve irrigation system	· Poor stakeholders' participation	· NIA · CIA Membership

		▪ Strong representation to revise NIA's cost recovery policies	▪ Current NIA's cost recovery policies	

3.5.3 Quilo-Quilo South CIA

The Quilo-Quilo South CIA members considered water pollution as a major problem (Table 13). According to them, some piggery farms located in nearby villages disposed the animal wastes on the river which is their source of irrigation water. As a result, the irrigation water that passed through their canals was laden with animal wastes. The effects of this waste -laden water on their farms have not yet been studied but farmers have observed that their farm productivity is high even if they use less fertilizer. The average rice yield in Quilo-Quilo South was 5.0-6.0 tons per hectare compared to 3.0-3.5 tons per hectare in Callejon-Del Valle. They plan to have the nutrient content of their irrigation water be analyzed but they do not have the capability to do so. They are hoping that the project team can facilitate this water quality analysis.

Another problem mentioned by CIA members was water distribution conflict. Despite their established policies to regulate water allocation, full compliance by all members was difficult to attain. For instance, during summer months, priority should be given to those whose farms are located downstream. However, some upstream farmers do not want to give way and would open the gate by themselves. The officers proposed to strengthen their information and education campaign to improve the members' appreciation and understanding of CIA policies and proper water management strategies. Farmers should also be encouraged to practice alternate wetting and drying technique.

The CIA members also raised the problem of heavy water loss, particularly in the sections of lateral canals that have not yet been cemented. The financial assistance that they got was not enough to pave the full length of the canal and about 500 meters remains unpaved. They thought that such financial assistance a grant from government but found out later that it was a loan that will be added to their current loan from NIA and therefore, subject to cost recovery agreement.

Table 13. Summary of Quilo-Quilo South CIA plan based on perceived problems and vulnerability assessment

Issue/Problem	Current Strategy to Address the Problem	Other Options that Could be Adopted	Constraints	Possible Sources of Support
Polluted water from upstream piggery farms	Ask for support and assistance from local government re solid waste management	▪ Seek support from Local Government Unit ▪ Study the beneficial/adverse effects of polluted water on rice production	▪ Proper coordination and support from LGU ▪ Technical Capability of CIA	▪ LGU ▪ UPLB
Water distribution	Conduct dialogues with	Strengthen Information, Education	Poor cooperation by some members	▪NIA ▪CIA

conflict	uncooperative members	and Communication activities		Membership
Water loss due to unfinished concreting of lateral canals	Seek financial assistance from NIA	Use Irrigation Service Fee collection for CIS improvement	Irrigation policies limit the use of ISF	▪NIA ▪CIA Membership

3.5.4 San Lorenzo CIA

This CIA identified two major problems (Table 14). They experienced water allocation conflict, particularly during dry months due to insufficient water supply and members' poor compliance with water allocation policies. They installed shallow tube wells and undertook dam and canal repair to augment water supply and improve the dam's storage capacity and water distribution system. They also plan to conduct massive information and education of their members on alternative water management and rice production technologies such as AWD to improve water use efficiency and minimized water loss due to poorly maintained irrigation canals.

The farmers' rice field were also said to be exposed to high risk of flooding due to highly degraded watershed condition. As a current strategy, the CIA is undertaking reforestation of the watershed. In addition, sustained watershed management was proposed to ensure water availability and reduced the risk of flooding.

Table 14. Summary of San Lorenzo CIA plan based on perceived problems and vulnerability assessment

Issue/Problem	Current Strategy to Address the Problem	Other Options that Could be Adopted	Constraints	Possible Sources of Support
Water distribution conflict due to insufficient water supply	▪ Install STW ▪ On-going repair of the dam and canals	Educate members on alternative water management (e.g. AWD)	Resource persons for information and education campaign activities	Academic institutions (e.g. UPLB)
High risk to flash floods	Reforestation of watershed	Watershed management		

3.5.5 Tubig Biyaya CIA

The major problem raised by the CIA members was the decreased in the dam's storage capacity due to heavy siltation (Table 15). Silt and sediment had built up through the years because the CIA was not able to dredge the dam in the recent years due to conflict of policies with other government agencies.

In the past, the CIA in partnership with the local government and with the assistance of a hydroelectric power company conducted dredging activities. The dredged materials were used by the local government in their infrastructure development projects. However, in the recent years the hydroelectric power company stopped their financial support. This compelled the CIA to generate financial resources to fund the dredging activities by selling dredged materials to private entities. However, such sale was found violating the Provincial Mining Regulatory Board (PMRB) policy that led to the imprisonment of some CIA officials.

One strategy currently being done by the CIA is to increase the dam's water storage capacity by putting sandbags on top of the dam crest. However, while this is a practical and low budget solution, it was also temporary since the sandbags can be easily washed off by raging flood waters. The CIA suggested to increase the dam's crest height by adding either a permanent concrete structure or panel boards. However, it is inadvisable since the original structure is very old and the foundation is already weak.

Some long term solutions that were recommended by the project team were to construct check dams (*sabo* dams) upstream to catch silts and prevent it from reaching the main dam and to continuously dredge the silts in the dam to increase storage capacity. To address the policy conflict with PMRB, the project team made representations with DENR for them to intervene and facilitate the resolution of the conflict. The CIA shall coordinate with PMRB and request guidance in the disposal of dredged materials. DENR recognized that dredging the silt from the dam can help alleviate food security and flood control problems that are greatly felt in the Philippines not only during typhoon season but even during monsoon rain season.

A related problem to dam siltation was the watershed degradation. Reforestation activities have been on-going but were not enough to cover the entire watershed. More concerted efforts that will involve the local government, private companies and youth volunteers are recommended to sustain water management activities. A rigorous IEC campaign to encourage the youth to help in reforestation activities are being planned by the CIA.

Table 15. Summary of Tubig Biyaya CIA plan based on perceived problems and vulnerability assessment

Issues/Problems	**Current strategy to address the problem**	**Other options that could be adopted**	**Constraints**	**Possible Sources of Support**
Decrease to dam's storage capacity due to siltation	Dredging	Construction of check dams (sabo dams) upstream to catch silts and prevent it from reaching the main dam	▪ Financial constraints and feasibility study ▪ Conflict with PMRB	▪ NIA ▪ PMRB ▪ DENR
	Submitted proposal to NIA to build SWIP near the dam	Continuous dredging of the silts in the dam to increase storage capacity		▪ NIA ▪ LGU
	Laying of sand bags on top of the dam crest to increase water level, thus			

	increasing storage capacity			
Watershed degradation	Reforestation in partnership with the *barangay* and a private company	Training of youth volunteers to sustain reforestation and forest protection activities		▪ LGU ▪ Private Company ▪ Youth Organization

4.0 Conclusions

The general objective of the project is to increase awareness, knowledge and capability of CIAs on alternative irrigation water management, climate forecast application, rice production systems and social mobilization, and recommend measures to replicate good practices in other areas of the country. Specifically, it aimed to: 1) assess the irrigation water management practices of CIAs and the problems they encountered; 2) conduct lectures and workshops on alternative water management strategies and social mobilization; 3) assist CIAs in preparing alternative water management and institutional development plans for optimum irrigation water allocation, particularly, during extreme weather events; and 4) recommend measures to replicate good practices in other areas of the country.

The CIAs/CISs studied differ largely in terms of number of years in existence, land tenure status of members, age of the CIS, ability to irrigate its potential service area; ISF collection efficiency, condition of the dam and the entire irrigation system, financial standing, cost recovery compliance, and O&M program. Tubig Biyaya CIA appears to be the strongest of all the CIAs studied while Callejon-Del Valle CIA appears to be constrained by many problems such as the need for more social mobilization and institutional support.

The strength of the CIA is critical to effective water management and system O&M. Strong leadership and cooperation among members, as shown by Tubig Biyaya, Bancuro and Quilo-Quilo CIA, are the key to effective water management.

The lectures enlighten the CIAs on the efficient use of water in rice production system and other possible options that could complement or improve their current water use practices. The Irrigation Management Plan drafted by the CIAs based on the vulnerability and capability assessment provides broad guidance for water management and strategic directions regarding how water should be managed as well as how the CIAs could enhance its institutional capacity. Other irrigation associations in the country and the region can learn from the lectures, lessons and experiences of the partner CIAs.

Some of the conclusions that can be derived from this study are as follows:

1. Climate change responsive water management and rice production technologies such as alternate wetting and drying and the use of drought or submergence resistant rice varieties have long been introduced to farmers. However, adoption of these practices is low due to the farmers' lack of understanding of their advantages or at least comparability with their traditional practice of constantly flooding their rice fields. The project hopes to help disseminate these technologies through the handbook on Irrigation Management Planning for Communal Irrigation System in the Philippines.

2. Poor cooperation among members of the Callejon-Del Valle CIA which is aggravated by the fact that most of them are not actual tillers and do not reside in the village are the main reasons for their low participation in CIS operation and management activities, low ISF collection rate and therefore their inability to meet their cost recovery commitment. In general, membership to the CIA should be limited to actual farm operators and village residents to improve communication and enhance cooperation, trust and confidence to CIA officials and compliance with CIA policies.

3. The government's cost recovery policy is not clear to most CIA members. They could not comprehend why they are asked to pay for the loan to finance dam construction when they were not involved in its planning and decision-making. This is one reason why ISF collection rate is low. This reaction is understandable since some of them were not yet into farming when the system was built. Moreover, most farmers are averse to credit due to the cultural stigma attached to being a debtor. It may be necessary to review the government's irrigation policy to make it socially inclusive. The government should not subject the CIS to cost recovery just like the national systems but CIAs should be responsible for its operation and maintenance for which the collected ISF should be allocated.

4. Most of the systems studied have low water use efficiency due to either system deterioration, or poor design and construction. The applicability of alternative water supply sources (e.g. STWs) and various water harvesting techniques (e.g., SWIPs, SFR) should be assessed to determine if any of these can help supplement the irrigation requirements of the crops. This can form part of the government's flood control and food security programs.

5.0 Future Directions

The policy issues addressed by the project would require follow up activities to ensure that concerned policy makers and other stakeholders have taken actions towards these. Given the expected changes in water resource availability associated with climate change, there should be efforts, e.g., by DA, to promote changes in rice production schemes (e.g., variety, cropping systems). NIA should continue capacity building programs to help CIAs adapt to the changing climatic conditions. There should also be programs that will encourage IA members' cooperation in implementing contingency plans.

There should be efforts to establish mechanisms for institutional arrangements between NIA, CIA and LGU that will enhance the phasing-in of LGUs in irrigation system management. There should be an enabling environment for replicating and sustaining in the long-term the knowledge gained by the CIA and LGU officials to effectively apply and operate the system that will be set up to mitigate climate change impact on irrigation service delivery.

The outcomes of this project have instigated to disseminate information further to help the partner CIAs in improving their management skills and capacity. This has led to writing a handbook that will be circulated to IAs to provide them with an overview and situational analysis of irrigation systems, as well as guide them in improving their systems, making strategic plans and adopting proper adaptation options and technologies in irrigation management.

The research however acknowledges that sustained implementation of the irrigation management plans may encounter problems due to the weak organization and the difficulty in mobilizing the CIA members specially the share tenants. It is therefore important to also increase the interest and commitment of members through proper policies that the IAs may adopt. Through the project, the exchange of knowledge and experiences has greatly helped the partner CIAs in increasing their awareness and skills on effectively managing their systems.

A review of irrigation policies is a potential area for further work. A more socially inclusive policy is needed in order to properly address the needs of irrigation systems and IAs. It is important to look at awareness raising and capacity building of IAs and not just the Local Government Units.

References

Follow a standard format when citing your references

Bouman BAM, Tuong TP. 2001. Field water management to save water and increase productivity in irrigated rice. Agric Syst. 93:43-60.

Lampayan RM, Bouman BAM, de Dios JL, Lactaoen AT, Quilang EJP, Tabbal DF, Llorca LP, Norte TM, Soriano J, Corpuz AA, Espiritu AJ, Malasa RB, Vicmudo VR. 2003. Technology transfer for water savings (TTWS) in Central Luzon, Philippines: results and implications. Proceedings of the 53rd Philippine Agricultural Engineering Annual National Convention, 21-25 April 2003, Waterfront Insular Hotel Davao, Davao, Philippines. p 239-251.

Ofrecio, B.P. 2006. Participatory Development and Management: A Cornerstone of Philippine Irrigation Program. *Journal of Developments in Sustainable Agriculture* 1:1–5. Available at: http://www.jstage.jst.go.jp/article/jdsa/1/1/1/_pdf.

Sharma, B.R. 2006. Crop Water Requirements and Water Productivity: Concepts and Practices. Lecture Material. College of Agricultural Engineering, Punjab Agricultural University, Ludhiana. Available at: www.waterandfood.org/gga/.../BRSharma_CWR&WP.pdf.

Websites

www.nia.gov.ph

www.ndcc.com

Appendix A.

WATER USE IN LOWLAND RICE-BASED PRODUCTION SYSTEM AND INTERVENTIONS UNDER WATER-LIMITING CONDITIONS

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Water and Plant Processes

Water influences the growth and development of plants through the following: i) it serves as a reactant in many biological reactions; ii) it enters into the structure of many biological molecules; iii) it serves as a medium for transport of nutrients and other substances in the plant; and iv) it helps regulate favorable plant temperature. Water deficiency in crops influences the level of productivity and yield of crops. Major plant processes affected by water deficiency are photosynthesis, respiration, carbohydrate metabolism, assimilate translocation, dry matter partitioning, and nutrient uptake and assimilation.

The effect of drought on photosynthesis for instance, is through reduction of leaf area, stomatal closure, decrease in chlorophyll in mesophyll cells and bundle sheath cells. Initially, respiration increases as a result of water deficit due to increased starch hydrolysis to sugar that provide more substrates for respiration. Respiration rate decreases with increasing degree of water deficit in plants. Carbohydrate metabolism is greatly reduced in water-stressed leaves due to reduction in α-amylase.

Translocation of photoassimilate from the leaves is reduced by water deficiency in the leaf during daytime, although it is increased during night time. The reduction in translocation is due reduced source or sink activity rather than direct effects on the capacity of conducting system. The partitioning of photosynthates can be changed by drought. This is shown by the reduction in quantity of economic yield in relation to total biological yield (harvest index), that could be attributed to abortion of flowers, grains and reduction in number and size of grains due to drought stress.

Ion uptake is not seriously affected under moderate water deficit conditions, although under severe drought conditions ion absorption and movement is reduced due to restricted movement of minerals in drying soils and from cell to cell upon uptake. Under water stress condition, nutrient assimilation such as to amino acids and proteins is adversely affected by drought stress.

In general, drought stress reduces crop productivity due to sequential disruption of metabolic processes from the sequestration of inputs from the air and soil for photosynthesis and other related physiological processes up to dry matter partitioning, and is apparently reflected in the level of economic yield produced (Rimando et al. in press).

Effect of Drought on Rice Yield and Yield Components

Yield reduction in rice due to drought stress could be traced from the development of yield components which are developed at different stages of rice growth and development. There are four components of yield, sometimes referred to as yield-determining components, namely: i) number of panicles per unit area; ii) number of spikelets per panicle; iii) percent filled spikelets; and iv) grain weight as shown in Figure 1.

The number of panicles per unit area is reflective of the production of tillers that occurs during the vegetative stage. The duration of this stage is dependent on the growth duration of the rice cultivar or variety. For instance, maximum tillering occurs at 42 days after transplanting in appropriately spaced transplanted rice crop. Vegetative stage ends at panicle initiation stage or ‘paglilihi’. Drought occurrence at this stage could be minimal to severe, depending on the time of stress occurrence. If drought occurs during active tillering, tiller and leaf area production could be significantly affected, and the desired tillers, leaf per hill, and canopy closure cannot be attained. Rice crop may recover if rewatered with ample time to resume tillering before the onset of panicle initiation.

The development of spikelets within a panicle, from panicle initiation up to flowering or ‘pagsapaw’, occurs during reproductive stage. The duration of this stage is about 35-36 days but can be shorten or lengthen by few days based on the prevailing climatic condition, such as abnormal temperatures or presence of environmental stresses. Within 35-36 days, panicle branches, spikelets and flower components are developed while the developing panicle travels from the base of the plant upward. Booting or ‘pagbubuntis’ occurs at 11 days after panicle initiation, while the formation of spikelets starts at 18 days before flowering or anthesis. The most sensitive time during reproductive stage to stresses, such as drought, is within the 2 weeks before flowering. Severe water stress may cause significant reductions in number of spikelets or failure of the panicles to come out (panicle exertion) of the stalk.

Percent filled spikelets is calculated using the formula: Percent Filled Spikelets = [(Number of Filled Spikelets)/ (Number of Filled + Unfilled Spikelets)] x 100. Percent filled spikelets is determined during flowering (includes pollination and fertilization), and during the subsequent grain filling stage which will last for about 30 days. Grain filling stage could be either shorten or lengthen by few days based on the prevailing condition such as abnormal temperatures or presence of environmental stresses. Drought stress during flowering may result to significant number of unfilled spikelets due to the disruption of pollination and fertilization process. After fertilization, some spikelets may not be filled up, particularly those with weaker source-pulling capacity. Hence, flowering stage and few days after flowering are most sensitive to drought stress, since it would result to a significant number of unfilled spikelets.

Grain weight development occurs during grain filling stage that will last for 30 days after flowering. The most sensitive to water stress during this stage is the first 15 days which covers the milk and soft dough stages. Beyond 15 days after flowering small gain in weight takes place, particularly under tropical condition. This stage could be shortened or lengthened by few days, particularly during hotter and cooler days or elevated areas, respectively. Water stress during the first 15 days may result to empty or partially-filled spikelets, hence reduction in grain weight. The recommendation to withdraw water at 2-3 weeks before harvest may vary with the water holding capacity of the soil. For instance, this could be delayed for few days in light-textured soils.

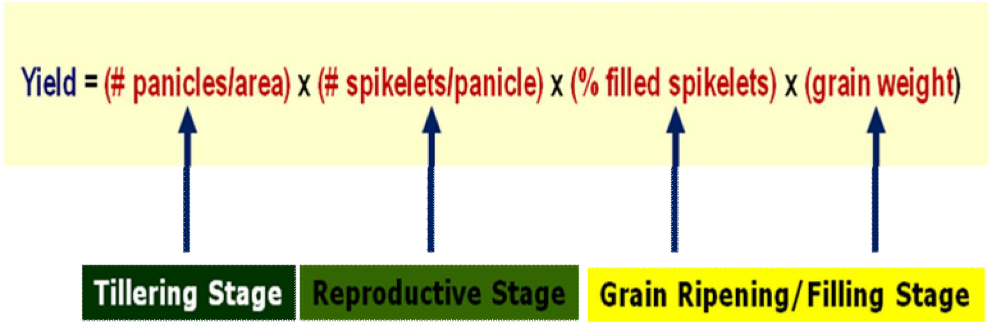


Figure 1. Rice yield-determining components and the stage of their development.

Water Balance and Water Use in Lowland Rice Field

Lowland rice field is usually prepared under wet condition, wherein: soaking, plowing, and puddling through harrowing or rotavation are carried out under saturated or submerged condition. Rice is established in a saturated or ponded with about 2 cm water field in three ways: i) by transplanting 2-3 week-old seedlings that are separately raised in seedbeds; ii) by direct wet-seeding - broadcasting or row-seeding of pre-germinated seeds into a wet soil; or iii) by direct dry-seeding - broadcasting or row-seeding of dry seeds into a dry or moist soil in the field.

Before transplanting or direct-seeding, water is needed during land preparation, i. e., for flooding or soaking (from few days to few weeks) before and during the primary tillage (1-2 plowing), secondary tillage (1-2 harrowing or rotavation), and final harrowing/leveling. After the final harrowing, the field is left flooded for few days before transplanting or direct-seeding. The duration of gaps between tillage activities may depend on the availability of water, seedling transplants, field labor and other farm considerations. The amount of water used for wet land preparation ranges 100-150 mm (about 1000-1500 cm^3 ha^{-1}) when the duration between soaking and transplanting is short (few days) or when the crop is direct wet seeded. The requirement during this period may increase up 940 mm (9400 cm^3 ha^{-1}), under poor water management, unfavorable soil water retention properties, longer turnaround time between soaking and transplanting/direct-seeding (up to 2 months) (Tabbal et al., 2002 as cited by Bouman et al., 2007).

After crop establishment, the soil is usually submerged with a 2-5 cm layer of water starting 5-10 days after sowing or transplanting (depending on the drying rate of the soil) until 2 weeks before harvest to provide the water requirement for rice growth, and control weeds and pests at varying stages of rice growth and development (Figure 2). A mid-season drainage is recommended to enhance root growth and development, but this recommended practice is not usually done in the field particularly during wet season when water levels cannot be controlled or during dry season when irrigation water is limiting.

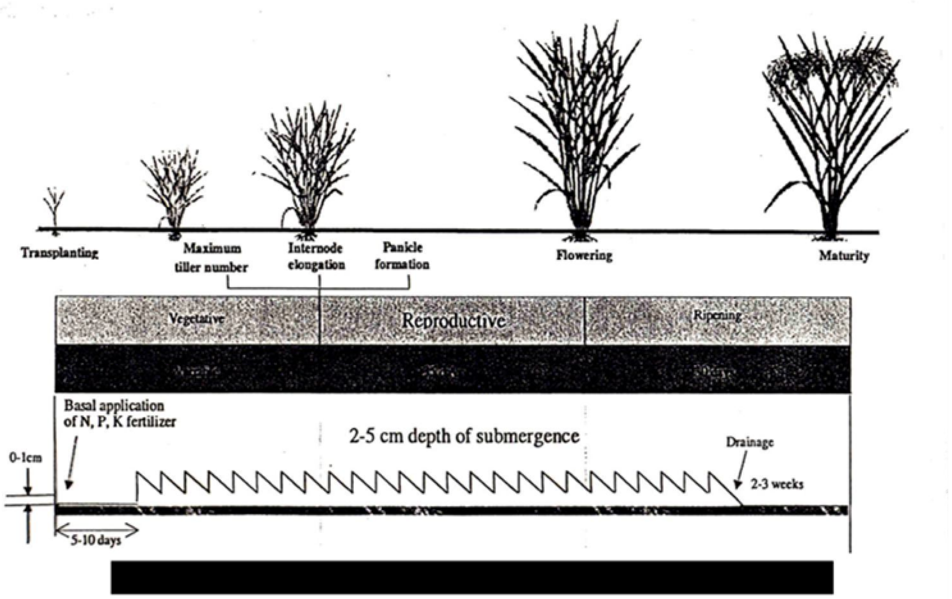


Figure 3. Water management in flooded lowland rice field (IRRI).

During crop growth and development, water is also lost from the rice field through evaporation, transpiration, runoff, seepage, and percolation. Runoff, seepage, and percolation are considered losses from the field. On the other hand, transpiration is a gain as it contributes to rice growth and development through temperature regulation and other physiological or metabolic processes.

The water balance of a lowland or wetland rice field, as shown in Figure 3, consists of: i) the inflows by irrigation, rainfall, and capillary rise; and ii) the outflows by transpiration, evaporation, overbund flow, seepage, and percolation. Capillary rise is the upward movement of water from the groundwater table. There is a continuous downward flow of water from the puddled layer to below the plow pan (percolation) that prevents capillary rise into the root zone. Capillary rise is usually neglected in lowland rice fields, although can be a source of water in dryland or upland field as capillary rise may move into the root zone with advancing water deficit in the upper layer of the soil (Bouman et al., 2007).

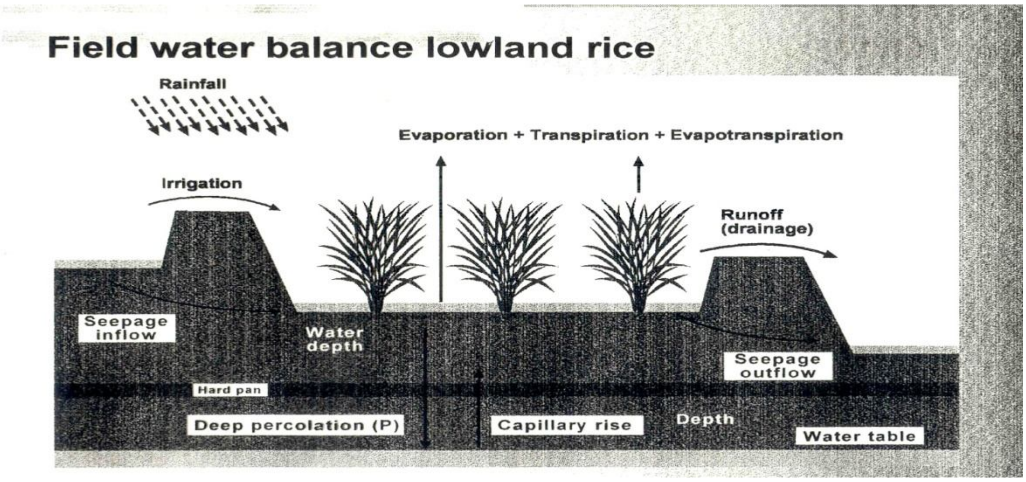


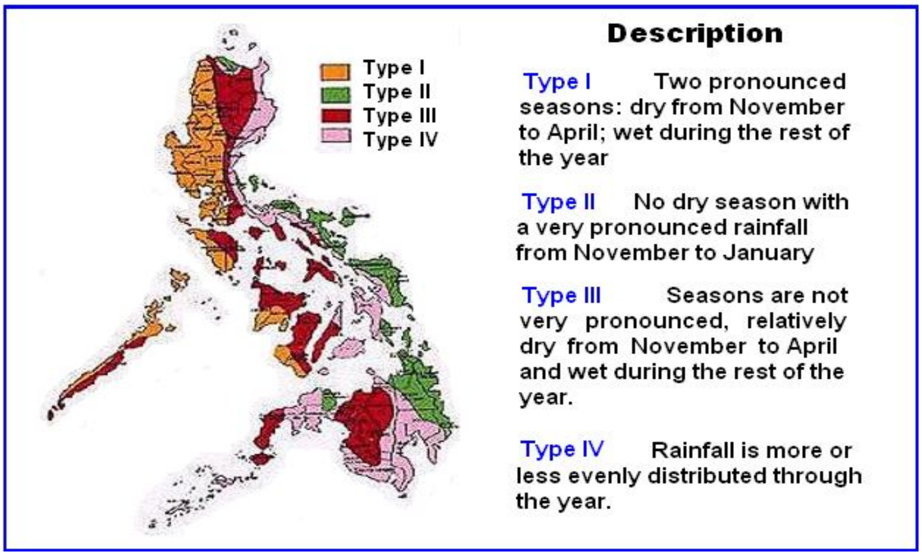
Figure 3. Field water balance in a bunded lowland rice field (IRRI).

Typical values of evapotranspiration (evaporation + transpiration) rates in rice fields are 4-5 mm d^{-1} during wet season, and 6-7 mm d^{-1} during dry season (Tabbal et al., 2002 as cited by Bouman et al., 2007). During the crop growth period, about 30-40% of evapotranspiration is evaporation (Bouman et al., 2005). Seepage is generally small in well-maintained bunds, but this may become significant depending on: i) soil physical properties of the rice field; ii) maintenance of the bunds; and iii) depth of the water table. The percolation rate of a rice field on the other hand, is affected by soil properties, such as: structure, texture, bulk density, mineralogy, organic matter content, and salt type and concentration (Wickham and Singh, 1978 as cited by Bouman et al., 2007). Water losses by seepage and percolation account for about 25-50% of all water inputs in heavy soils with shallow groundwater tables of 20-50 cm depth (Cabangon et al., 2004, Dong et al., 2004 as cited by as cited by Bouman et al., 2007), and 50-85% in coarse-textured soils with deep groundwater tables of 1.5-m depth or more (Singh et al., 2002 as cited by Bouman et al., 2007).

Based on IRRI studies, the entire rice production (land preparation to harvest) of a 100-day duration rice variety may require: 175-750 mm for land preparation; 400-500 mm for evapotranspiration during wet season or 600-700 mm during dry season; and 100-200 mm for seepage and percolation losses in heavy clays or 2,500-3000 mm in loamy/sandy soils. In total, about 675-4450 mm (6,750-44,500 cm^3 ha^{-1}) or a typical value (average) of 1,500 mm (15,000 cm^3 ha^{-1}) of water is needed to establish, grow and harvest a 100-day rice variety. To produce 1 kg of unprocessed rice under irrigation, about 1500-5000 L of water. The wide range of water requirement depends on the prevailing climate, soil characteristics and rice variety (Bouman et al., 2007).

Rainfall Pattern and Cropping Sequence in Lowland Rice-based Production System

The Philippines has four climatic types as proposed by Fr. Corona using rainfall data from 1951 to 1980. This type of classification of climate is based on the distribution of rainfall within a year. A month is considered a dry month when cumulative monthly rainfall is less than 50 mm. Using average monthly distribution of rainfall at different locations of the country, four general types of rainfall pattern were defined as shown in Figure 4.



Description

Type I Two pronounced seasons: dry from November to April; wet during the rest of the year

Type II No dry season with a very pronounced rainfall from November to January

Type III Seasons are not very pronounced, relatively dry from November to April and wet during the rest of the year.

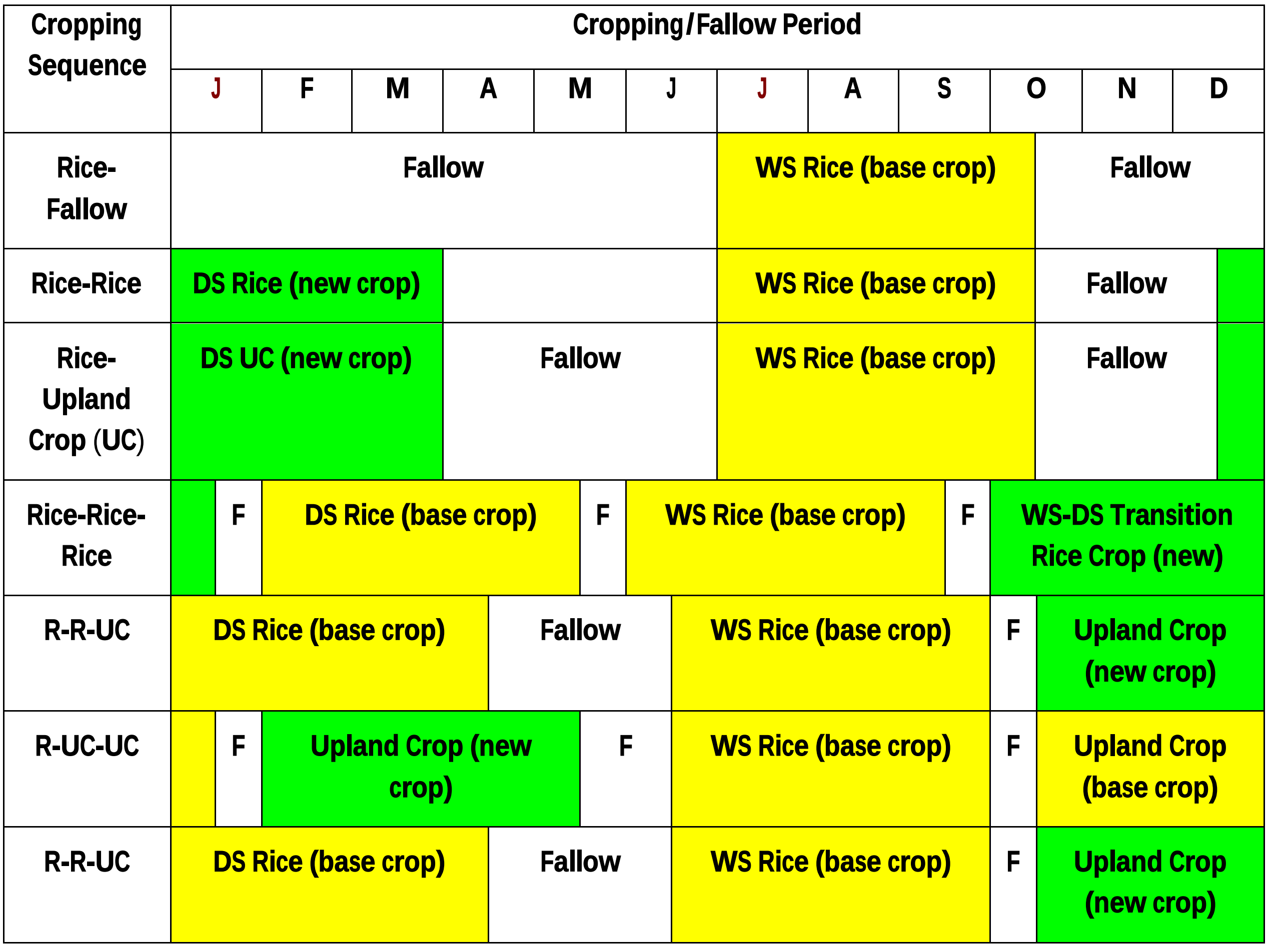
Type IV Rainfall is more or less evenly distributed through the year.

Figure 4. Climate Map of the Philippines based on the Modified Corona's Classification (PAGASA, 2011 http://kidlat.pagasa.dost.gov.ph/cab/statfram.htm).

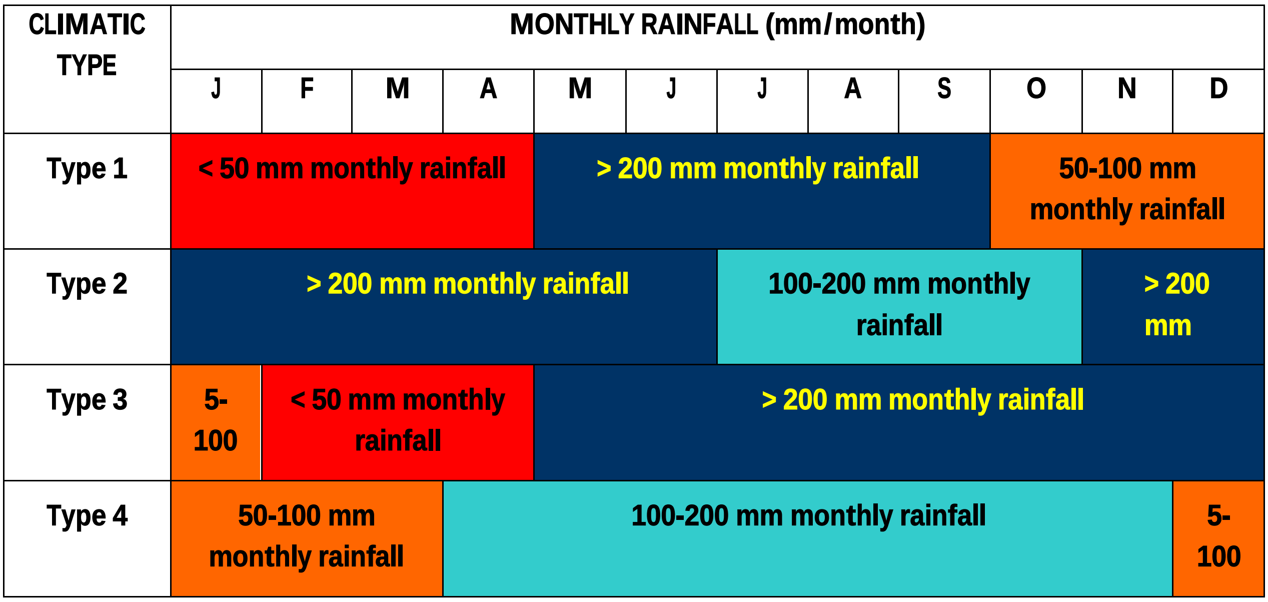
In a lowland rice-based production system, wet season rice crop (July-October) can be classified as an irrigated, when rainfall is inadequate to support the crop water requirement within the season and supplementary irrigation is applied. For dry season rice crop (December-March), full or supplemental irrigation is needed during the season, depending on the amount of rainfall during the season. Areas with distinct dry and wet seasons (Type I) generally require irrigation during the dry season. Areas with short dry periods (Types III and IV) or with well-distributed rainfall throughout the year (Type II) may need supplemental irrigation when rainfall is limiting. Total or supplemental irrigation is practiced during dry or wet seasons particularly during the years of El Nino occurrence, while lessen during the La Nina years.

Cropping intensity and crop sequences are highly dependent on the availability of water to support one or more rice crops within a year. When water, whether from rainfall or irrigation, is limiting during dry season, farmers opt to replace the supposedly dry season lowland rice crop with upland crop that requires lower amount of water compared with lowland rice. Under conditions of extreme inadequacy or unavailability of water during dry season, farmer may decide not to plant any crop and wait for the next wet season.

Varying cropping sequences are practiced at site-specific level, depending on the available amount of water for crop use during the growing period. Some of the crop sequences being practiced in rice-based areas of the country, are: i) triple rice cropping system (rice-rice-rice); ii) double rice cropping system (rice-rice); iii) rice-upland crop; and iv) rice-fallow (Figure 5).



Cropping Sequence	Cropping/Fallow Period											
	J	F	M	A	M	J	J	A	S	O	N	D
Rice-Fallow	Fallow						WS Rice (base crop)				Fallow	
Rice-Rice	DS Rice (new crop)						WS Rice (base crop)				Fallow	🟩
Rice-Upland Crop (UC)	DS UC (new crop)			Fallow			WS Rice (base crop)				Fallow	🟩
Rice-Rice-Rice	🟩 F	DS Rice (base crop)			F	WS Rice (base crop)			F	WS-DS Transition Rice Crop (new)		
R-R-UC	DS Rice (base crop)			Fallow		WS Rice (base crop)				F	Upland Crop (new crop)	
R-UC-UC	F	Upland Crop (new crop)			F	WS Rice (base crop)				F	Upland Crop (base crop)	
R-R-UC	DS Rice (base crop)			Fallow		WS Rice (base crop)				F	Upland Crop (new crop)	



CLIMATIC TYPE	MONTHLY RAINFALL (mm/month)											
	J	F	M	A	M	J	J	A	S	O	N	D
Type 1	< 50 mm monthly rainfall				> 200 mm monthly rainfall					50-100 mm monthly rainfall		
Type 2	> 200 mm monthly rainfall						100-200 mm monthly rainfall				> 200 mm	
Type 3	5-100	< 50 mm monthly rainfall			> 200 mm monthly rainfall							
Type 4	50-100 mm monthly rainfall			100-200 mm monthly rainfall								5-100

Figure 5. Possible crop sequences or rotation in a rice-based cropping system based on rainfall distribution under different climatic types prevailing in the country.

Rainfall Availability and Cropping Schedules in Batangas and Quezon Provinces

Batangas Province

The monthly rainfall pattern in Batangas Province is shown in Figure 6. Considering a minimum monthly rainfall requirement of 150-200 mm to support a lowland rice crop, the rainfall during the months of June to October is adequate to support a wet season rice crop. The subsequent dry season cropping which covers November to March cannot rely on the rainfall alone. Hence, irrigation water is needed during dry season.

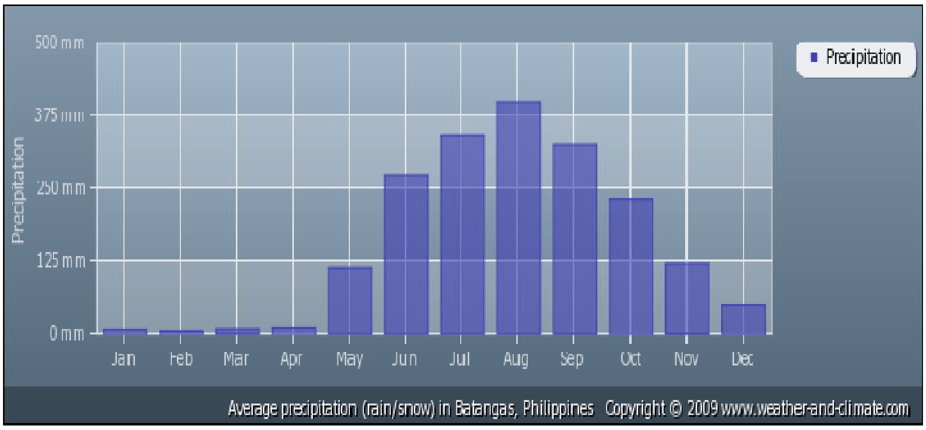


Figure 6. Monthly rainfall pattern in Batangas Province.

Quezon Province

Based on the monthly rainfall pattern of Quezon Province (Figure 7), and a minimum requirement of 150-200 mm rainfall per month to support a lowland rice crop, the rainfall during the months of June to October is adequate to support a wet season rice crop. Although rainfall occurs during the subsequent dry season cropping months, covering November to March, the amount of rainfall from January to March is inadequate. Thus, irrigation water is needed during these months, which coincides with the reproductive and grain filling stages of the dry season rice crop.

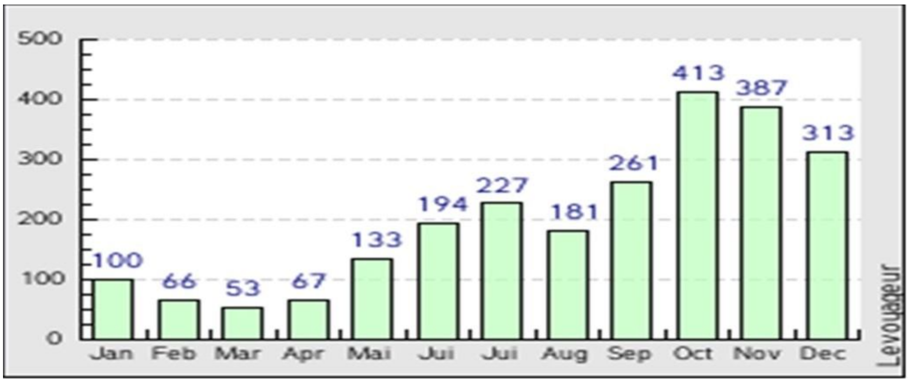


Figure 7. Monthly rainfall pattern in Quezon Province (www.levoyageur.net).

Possible Interventions Based on Water Availability for Lowland Rice Production in Batangas and Quezon Provinces

There are three situations wherein possible interventions of varying degrees can be done in a specific lowland rice area, such as: i) areas with existing irrigation facilities and adequate water source for wet and dry seasons; ii) areas without or inadequate irrigation facilities while potential source of water is available; and iii) areas without or inadequate irrigation facilities and potential source of water to augment the existing water use is not available.

Another aspect to be considered is the desire of farmers in given area (e. g. CIA) to either increase their rice cropping index (number of crops harvested per year in a given area) or maintain their current cropping index. The possible interventions under the above-listed scenarios are presented in Table 1.

Table 1. Three scenarios wherein possible interventions that can be imposed in a specific lowland rice area.

Scenario	Intervention	Remarks
Areas with existing irrigation facilities and adequate water source for wet and dry seasons	• Improve the efficiency irrigation water delivery system[1].	• Service area of irrigation facility per cropping can be expanded due to irrigation water saved.
	• Further tapping of the water source[1].	• Additional irrigation water and water saved per cropping could increase cropping index from 2 to 3, with 3rd crop as rice or upland crop.
	• Impose water-saving cultural practices[2].	
Areas without or inadequate irrigation	• Improve the efficiency irrigation water delivery	• Additional irrigation water or water saved per cropping

facilities while potential source of water is available	system[1]. • Further tapping of the water source[1]. • Impose water-saving cultural practices[2].	could sustain a cropping index of 2, i. e. wet and dry season rice crops.
Areas without or inadequate irrigation facilities and potential source of water to augment the existing water use is not available	• Improve the efficiency irrigation water delivery system[1]. • Impose water-saving cultural practices[2].	• Water saved per cropping could sustain a cropping index of 2, i. e. enough to support a wet season crop and dry season crop which could be either rice or upland crop.

[1] Described in a separate paper

[2] Elaborated in the succeeding section of this paper

Cultural Management Practices under Water-limiting Conditions

Adaptation of lowland rice production under water-limiting conditions may involve the following practices: i) fallow period or turn-around time between cropping; ii) straw/stubble and weed management before land preparation; iii) use of rice varieties, iv) crop establishment; v) water management during crop growth period; and iv) selection of appropriate crop sequence or crop rotation. Specifics are presented in Table 2.

Table 2. Cultural management options that can be adapted under water-limiting lowland rice production.

Cultural Practice	**Water-saving or Adaptive Practice under Water-limiting Condition**
Fallow period or turn-around time between cropping	• Fallow period between wet and dry seasons can be shortened to take advantage of the tail-end of the wet season rainfall for the subsequent dry season crop. • Need for earlier seedling nursery establishment and transplanting for transplanted rice.
Straw/stubble and weed management before land preparation	• Appropriate straw management (decomposition) and stubble/weed (mowing/incorporation if doable) to reduce water requirement during land preparation.
Use of rice varieties	• Use of drought-tolerant varieties. • Use of short-duration varieties during wet and dry seasons, particularly avoid the exposure of the dry season crop to the water-limiting months of February and March.
Land preparation	• Short periods between tillage operations, i. e. between plowing, harrowing/rotavation, and final harrowing/leveling to avoid longer period of soaking time. • Appropriate land leveling. • Intentional development of plow pan to lessen percolation.
Crop establishment	• Practice direct-seeding if doable and as long as problems

	(e. g. weeds and snails) arising from this practice are manageable.
Water management during crop growth period	• Practice saturated soil culture or alternate wetting and drying if water is slightly inadequate within the season, but potential problems, such as weeds and snails during the first 30 days are manageable and possible yield reduction arising from these practices is acceptable[1]. • Under severe water limitation, adapt aerobic rice production, i. e. planting rice like a corn – an upland crop culture[1].
Selection of appropriate crop sequence or crop rotation	• In lieu of aerobic rice culture, dry season crop could be replaced with any upland high-value crop suited to the soil property of the area, availability of water, with manageable harvesting/postharvest requirement, and with good market demand.

[1] Described in a separate paper

Summary

Water influences the growth and development of plants. Major plant processes affected by water deficiency are: photosynthesis, respiration, carbohydrate metabolism, assimilate translocation, dry matter partitioning, and nutrient uptake and assimilation. Drought stress reduces crop productivity due to sequential disruption of metabolic processes, i. e., from sequestration of inputs from the air and soil for photosynthesis and other related physiological processes up to dry matter partitioning, and is reflected in the level of economic yield produced.

Yield reduction in rice due to drought stress could be traced from the development of yield components which are developed at different stages of growth and development. There are four components of yield, sometimes referred to as yield-determining components, namely: i) number of panicles per unit area; ii) number of spikelets per panicle; iii) percent filled spikelets; and iv) grain weight.

Drought occurrence during active tillering could be significantly affect tillering and leaf area development, wherein the desired number of tillers, leaf area per hill, and canopy closure cannot be attained. Rice crop may recover if rewatered with ample time to resume tillering before the onset of panicle initiation. The development of spikelets within a panicle, from panicle initiation up to flowering occurs during reproductive stage, which usually last for about 35 days. The most sensitive period during reproductive stage to stresses, such as drought, is within the 2 weeks before flowering. Severe water stress may cause significant reductions in number of spikelets or failure of the panicles to come out (panicle exertion) of the stalk.

Percent filled spikelets is determined during flowering, and during the subsequent grain filling stage which usually last for about 30 days. Drought stress during flowering may result to significant number of unfilled spikelets due to the disruption of pollination and fertilization process. After fertilization, some spikelets may not be filled up, particularly those with weaker photoassimilate-pulling capacity, which is dependent on the position of the spikelets within a panicle. Hence, flowering stage and few days after flowering are most sensitive to drought stress, since it would result to a significant number of unfilled spikelets.

Grain weight development occurs during grain filling stage. The most sensitive to water stress during this stage is the first 15 days which covers the milk and soft dough stages. Beyond 15 days after flowering small gain in grain weight takes place, particularly under tropical condition. Water stress during the first 15 days may result to empty or partially-filled spikelets, hence reduction in grain weight. The recommendation to withdraw water at 2 weeks before harvest may vary with the water holding capacity of the soil. For instance, this could be delayed for few days in light-textured soils.

The water balance of a lowland rice field consists of the inflows by irrigation, rainfall, and capillary rise, and the outflows by transpiration, evaporation, overbund flow, seepage, and percolation. Capillary rise is usually neglected in lowland rice fields, although can be a source of water in dryland or upland field as capillary rise may move into the root zone with advancing water deficit in the upper layer of the soil. During crop growth and development, water is lost from the rice field through evaporation, transpiration, runoff, seepage, and percolation. Runoff, seepage, and percolation are considered losses from the field. On the other hand, transpiration is a productive water flow as it contributes to crop growth and development through temperature regulation and other physiological or metabolic processes.

Typical values of evapotranspiration rates in rice fields range 4-5 mm d^{-1} during wet season, and 6-7 mm d^{-1} during dry season. During the crop growth period, about 30-40% of evapotranspiration is the evaporation component. Seepage is generally small in well-maintained bunds. Percolation rates are higher in fields with deep groundwater tables (> 2 m depth) than for fields with shallow groundwater tables (0.5-2 m depth). Typical values of combined seepage and percolation ranges 1-5 mm d^{-1} in heavy clay soils to 25-30 mm d^{-1} in sandy and sandy loam soils. Water losses by seepage and percolation account for about 25-50% of all water inputs in heavy soils with shallow groundwater tables of 20-50 cm depth, while 50-85% in coarse-textured soils with deep groundwater tables of 1.5-m depth or more. Based on IRRI studies, about 1,500 mm (15,000 cm^3 ha^{-1}) of water is needed to establish, grow and harvest a 100-day rice variety. To produce 1 kg of unprocessed rice under irrigation, about 1,500-5,000 L of water. The wide range of water requirement depends on the prevailing climate, soil characteristics and rice variety.

In a lowland rice-based production system, wet season rice crop (July-October) can be classified as an irrigated, when rainfall is inadequate to support the crop water requirement within the season, and supplementary irrigation is applied. For dry season rice crop (December-March), full or supplemental irrigation is needed during the season, depending on the amount of rainfall during the season. Areas with distinct dry and wet seasons (Type I Climate) generally require irrigation during the dry season. Areas with short dry periods (Types III and IV Climates) or with well-distributed rainfall throughout the year (Type II Climate) may need supplemental irrigation when rainfall is limiting. Total or supplemental irrigation is practiced during dry or wet seasons particularly during the years of El Nino occurrence, while this is lessen during the La Nina years.

Cropping intensity and crop sequences are highly dependent on the availability of water to support one or more rice crops within a year. When water, whether from rainfall or irrigation, is limiting during dry season, farmers opt to replace the supposedly dry season lowland rice crop with upland crop that requires lower amount of water compared with lowland rice. Under conditions of extreme inadequacy or unavailability of water during dry season, farmer may decide not to plant any crop (fallow) and wait for the next wet season. Thus, varying cropping sequences are practiced at location-specific level, depending on the available amount of water for crop use during the season. Some of the crop sequences being practiced in rice-based areas of the country, are: i) triple rice cropping system (rice-rice-rice); ii) double rice cropping system (rice-rice); iii) rice-upland crop; and iv) rice-fallow.

Possible interventions for lowland rice-based production systems in Batangas and Quezon Provinces could be based on water availability. There are three situations wherein possible interventions of varying degrees can be done in a specific lowland rice-based production area, such as: i) areas with existing irrigation facilities and adequate water source for wet and dry seasons; ii) areas without or inadequate irrigation facilities while potential source of water is available; and iii) areas without or inadequate irrigation facilities and potential source of water to augment the existing water use is not available.

The possible location-specific interventions are: i) improvement of the efficiency irrigation water delivery system – wherein the service area of irrigation facility per cropping can be expanded due to irrigation water saved; ii) further tapping of the water source; and iii) through imposition of water-saving cultural practices. The last two interventions will result to additional irrigation water and water saved per cropping that could increase cropping index from 1 to 2 or 2 to 3, with 2nd or 3rd crop as rice or upland crop depending on the situation. The 1st and 2nd interventions are fully discussed in separate papers. For the recommended cultural management practices under water-limiting conditions (3rd intervention), adaptation of lowland rice production under water-limiting conditions may involve the following practices: i) fallow period or turn-around time between cropping; ii) straw/stubble and weed management before land preparation; iii) use of rice varieties, iv) crop establishment; v) water management during crop growth period; and iv) selection of appropriate crop sequence or crop rotation.

Water-saving or adaptive practice under water-limiting condition could be: i) shortening of the fallow period between wet and dry seasons to take advantage of the tail-end of the wet season rainfall for the subsequent dry season crop – this would require and earlier seedling nursery establishment and transplanting for transplanted rice; ii) appropriate straw management (decomposition) and stubble/weed (mowing/incorporation if doable) to reduce water requirement during land preparation; iii) short periods between tillage operations, i. e. between plowing, harrowing/rotavation, and final harrowing/leveling to avoid longer period of soaking time; iv) appropriate land leveling and intentional development of plow pan to lessen percolation; v) practice direct-seeding if doable and as long as problems (e. g. weeds and snails) arising from this practice are manageable; vi) Practice saturated soil culture or alternate wetting and drying if water is slightly inadequate within the season, but potential problems, such as weeds and snails during the first 30 days should be manageable and possible yield reduction arising from these practices is acceptable; vii) under severe water limitation, adapt aerobic rice production, i. e. planting rice like a corn – an upland crop culture; and viii) in lieu of aerobic rice culture, dry season crop could be replaced with any upland high-value crop suited to the soil property of the area, availability of water, with manageable harvesting/postharvest requirement, and with good market demand.

References

Bidraban PS, Tuong TP, Ladha JK. Eds. Water-wise rice production. Los Banos (Philippines): International Rice Research Institute. p. 237-246.

Bouman BAM, Lampayan RM, Tuong TP. 2007. Water management in irrigated rice: opting with water scarcity. Los Banos (Philippines): International Rice Research Institute. 54 p.

Bouman BAM, Peng SB, Castaneda AR, Visperas RM. 2005. Yield and water use of irrigated tropical aerobic rice systems. Agric Water Manage. 74:87-105.

Bouman BAM, Tuong TP. 2001. Field water management to save water and increase productivity in irrigated rice. Agric Syst. 93:43-60.

Cabangon RJ, Tuong TP, Castillo EG, Bao LX, Lu G, Wang GH, Cui L, Bouman BAM. 2004. Effect of irrigation method and N-fertilizer management on rice yield, water productivity and N-use efficiency in typical lowland rice conditions in China. Rice Field Water Environ. 2:195-206.

Dong B, olden D, Loeve R, Li YH, Chen CD, Wang JZ. 2004. Farm level practices and water productivity in Zanghe Irrigation System. Rice Field Water Environ. 2:217-226.

Kampen J. 1970. Water losses and water balance studies in lowland rice irrigation. PhD Dissertation, Cornell University, Ithaca, NY, USA. 416p.

PAGASA. 2011. http://kidlat.pagasa.dost.gov.ph/cab/statfram.htm. Accessed: 1 December 2011.
Singh AK, Choudhary BU, Bouman BAM. 2002. Effects of rice establishment methods on crop performance, water use and mineral nitrogen. In: Bouman BAM, Hengsdijk H, Hardy B,

RimandoTJ, Borromeo TH, Salazar BM, Sta. Cruz PC, Lalusin AG, Mercado MFO, Magnaye AMA. In press. Fundamentals of Crop Science. UP Los Banos, College, Laguna.

Tabbal DF, Bouman BAM, Bhuiyan SI, Sibayan EB, Sattar A. 2002. On-farm strategies for reducing water input in irrigated rice: Case studies in the Philippines. Agric Water Manage. 56:93-112.

Wickham TH, Singh VP. 1978. Water movement through wet soils. In Soils and Rice. Los Banos (Philippines): International Rice Research Institute. p. 337-357.

http://www.cgiar.org. Accessed: 8 November 2010.

http://www.riceworld.org/irrc/streams/aerobic%20rice.asp. Accessed: 23 November 2010.

http://books.irri.org/9789712202193_content.pdf. Accessed: 24 November 2010.

http:weather-and-climate.com. Accessed: 10 October 2011.

http://www.levoyageur.net Accessed: 1 December 2011.

ALTERNATIVE WATER MANAGEMENT FOR RICE PRODUCTION

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INTRODUCTION

Rice is the most important staple crop in the Philippines, and, because of its heavy water requirements, is also the biggest consumer of irigation water. It consume more than 50% of all irrigation water. However, said fresh water is becoming increasingly scarce. In many Asian countries including the Philippines, per capita availability declined by 40-60% between 1955 and 1990 and is expected to decline further by 15-54% over the next 35 years (stated by Gleik, IRRI 2003). The reasons include population growth, increasing urban and industrial demand, pollution and resource depletion.

As an example of the situation, IRRI 2003, stated that water from the Angat reservoir in Bulacan Province is increasingly diverted toward the Greater Manila Area (Pingali et al, 1997), water in the Agno River Irrigation System in Pangasinan Province is pollute with sediments and chemical from mining activities upstream (Castaneda and Bhuiyan 1993), and may irrigation system were destroyed and clogged by the earthquakes of 1990 and the Mount Pinatubo erruption in 1991 (NIA 1996). More to this, because of the dense population and close proximity to populace, rice production is of strategic importance to food security and poverty alleviation.

The government of the Philippines through its National Irrigation Administration (NIA), is dedicated to maintaining and enhancing irrigation water availability by infra structure development and maintenance and by the propagation of water-saving irrigation technologies (NIA 1996). However, with the global warming and effect of climate change, the decreasing availability of water for irrigated rice threatens food security in general and livelihood of farmers in particular.

Researchers have been looking for ways to decrease water use in rice production and increase its use efficiency. According to IRRI 2002, 17 million ha of irrigated rice may experience "physical water scarcity" and 22 million ha may have "economic water scarcity" by 2025 (Tuong and Bouman 2001). Several strategies are being pursued to reduce rice water requirements, such as saturated soil culture (Borrel et al 1997), alternative wetting and drying (Li 2001, Tabbal et al 2002). ground cover systems (Lin shan et al 2002), and raised beds (sing et al 2002). The relative advantages and disadvantages of the various technologies are not known and so are the potential or typical target domains in biophysical (climate, soil, hydrology) and socio economic terms.

Despite the amount of research spent on the development of water saving technologies, it is thought that actually very few of them are being adopted by farmers, with the exception of alternate wetting and drying technique in China (Tuong and Bouman 2002)

THE WATER BALANCE OF LOWLAND RICE

Lowland rice are flooded in nature, its water balance and water productivity are different from those of other cereals such as wheat and maize. Water input into the rice fields are needed to match the outflows by seepage, percolation, evaporation and transpiration (Figure 1).

Seepage is the lateral subsurface flow of water and percolation is the downflow of water below the root zone. Combine values of seepage and percolation vary fron 1-5 mm/day in heavy clay soil to 20-30 mm/day in sandy and loamy soils. Evaporation occurs from the ponded water layers and transpiration is water loss from the leaves of the plants. Combined evapotranspiration rates of rice field are 4-5 mm/day in the wet season and 6-7 mm/day in the dry season, and it can be as high as 10-11 mm/day in the sub tropical region before the onset of the monsoon.

Total seasonal water input into the rice field (rainfall plus irrigation) varies from 400 mm in heavy clay soil with shallow groundwater tables to more than 2000 mm in sandy or loamy soils with deep groundwater tables. 1300-1500 mm is a typical value for irrigated rice in Asia. Outflow of water by seepage and percolation account for about 25-50% of all water inputs in heavy soil with shallow water tables of 20-25 cm depth, and 50-85% in coarse-textured soils in deep water tables of 150 cm depth or more (IRRI).

Irrigated lowland rice is transplanted or direct (wet) seeded into puddled lowland fields. Land preparation consist of soaking, plowing, and puddling. Puddling is done not only to control weeds, but also to increase water retention, reduce soil permeability, and ease field levelling and transplanting (De Datta 1981). Soaking, a one time operation, requires water to bring topsoil to saturation and to create a ponded layer. After land preparation, there is an “idle period” until transplanting or direct seeding takes place.

The growth period of rice runs from establishment to harvest. During the crop growth, fields are typically flooded with 5-10 cm of water. Under flooded conditions, water is required to match several outflow processs. Because of standing water, hydrostatic pressure continuously “pushes” water downward throught the puddled layer, thus percolation and seepage takes place. Water is released into the air by evaporation from the ponded water layer, and transpiration by the crop. However, during land preparation and idle period, only evaporation takes place, whereas, during crop growth, both evaporation and transpiration occurs.

Of all outflows of water from the rice field, only transpiration is “productive” water use, as it leads to crop groth and yield formation. It is essential to plant growth because it provides cooling and is driving process for water flow in plants that carries nutrients from the roots to the shoot. Unproductive water losses were causes by seepage and percolation.

GROWTH STAGES OF RICE PLANT

Rice is germinated at 2-3 days depending on varieties. Seedling can be produce in 3-12 days in the field or in other designated areas specially those that were to be transplanted, or with the more developed tillers up to 17.5 days. Vegetative growth stage is 17-33 days, but stem development can also be observe during 25-33 days. From 33-50 days panicle initiation and booting could be seen, and so with the reproductive stage at 37-74 days where-in heading is developed within 52 58 days. Flowering is observed at 68-74 days, milk developed by the grain between 75-85 days. At 86- 105 days ripening of the grain is now observed and totally matured grains can be observe 102-120 days.

WATER MANAGEMENT STRATEGIES TO REDUCE WATER INPUT

Bouman and Tuong 2001, stated that reducing seepage and percolation flows through reduced hydrostatic pressure can be achieved by water management. Instead of keeping the rice field into continuously flooded with 5-10 cm of water, the floodwater depth can be decreased, the soil can be kept around saturation (SSC), or alternative wetting and drying (AWD). Under these management practice, the hydrology of the soil changes from anaerobic under flooded and SSC regimes to alternately anaerobic and aerobic under AWD. Ultimately, rice could be grown under completely aerobic conditions and the SP eliminated.

ALTERNATIVE WATER SAVING TECHNOLOGIES

Dependng on the situation at the system level, the technologies for water savings shall include but not limited to the following:

Dry Tillage – Dry tillage is recommended in order to save about 30% of the total water requirement in rice production. The water traditionally require for puddling the soil will be saved and therefore be used in directly irrigating the rice crop during emergence.. Usually traditional practice of the old farmers prepare the fields dry specially those that are situated in the rainfed lowland, the idea is to let the grasses exposed to the heat of the sunlight in order for the grasses to wilt and dried up, thus faster eradication of weeds were done.

Dry Seeding – dry seeding technique should be adopted in combination with dry tillage. Seeds will be sown and broadcasted, covered with soil and flash-irrigated, if necessary, to supply the moisture for germination and initial crop establishment. Appropriate weed control technologies should be practiced in coordination with the above indicated practice. Chemicals for weed control were also sprayed in time at dry land conditions for speedy weed elimination. Seeds to be sown were usually those that can emerge even with the moisture that developed in the soil during night time. Among the examples of upland varieties were taken from Philippine seedboard (PSB)/NSIC Rice Varieties listed from Philrice: PSB RC1 (Makiling) an IRRI variety; PSB RC3 (Ginilingang Puti) a traditonal variety; PSB RC5 (Arayat) IRRI variety; PSB RC7 (Banahaw) Philrice variety; NSIC RC9 (Apo) IRRI variety; and NSIC RC11 (Canlaon) by Philrice.

Alternate Wetting and Drying (AWD) or Controlled Irrigation (CI) – what is AWD or CI? Alternate Wetting and Drying (AWD) or Controlled Irrigation (CI), is a water saving technlogy that lowland (paddy) rice farmers can apply to reduce their water use in irrigated fields. In AWD, irrigation water is applied to flood the field a certain number of days after the disappearance of ponded water. Hence, the field is alternately flooded and non-flooded (allowed to be dried). The number of days of non-flooded soil in AWD between irrigations can be vary from 1 day too more than 10 days.

How to implement AWD? - a practical way to implemen AWD is to monitor the depth of ponded water on the fields using a "field tube" (Figure 2). After irrigation, the depth of ponded water will gradually decrease. When the water in the field has dropped to 15 cm below the surface level of the soil, irrigation should be applied to re-flood the field with 5 cm of ponded water. From on1 (1) week before flowering to one(1) week after flowering, ponded water can be maintain or kept at 5 cm depth. After flowering, during grain filling and ripening, water level can be allowe to drop again to 15 cm below the surface of the soil before re- irrigation.

AWD can be started a few days after transplanting (or with 10 cm tal crop in direct seeding). When the indication of many weeds is noted, AWD can be postponed for 2-3 weeks until weeds have been supprssed by the ponded water. Local fertilizer recommendatis as for flooded rice can be used. Apply Nitrogen fertilizer preferably on the dry soil just before irrigation.

Safe AWD?

The threshold of 15 cm water depth below the soil surface before re-irrigation is called "SafeAWD" as this will not cause any yield decline. In safe AWD, water savings are in the order of 15-30%. After creating confidence that the safe AWD does not reduce yield, farmers may experiment by lowering the threshold level fro irrigation to 20, 25, 30 cm depth 0r even deeper. Lowering the threshold level for irrigation will increase the water savings, but some yield penalty may occur. Such a yield penalty may be acceptable when the price of water is high or when water is very scarce.

References

B.A.M Bouman, Water-efficient Management strategies in Rice Producton, IRRI, 6p

Bouman BAM, Lampayan, RM., Saving Water: Alternaive Wetting and Drying, Rice Fact Sheets, IRRI, August 2009

FAO, Rising Water Productivity, Magazine, Spotlight /2003

IRRI, Integrated Water Management in Rice Production-Technology Transfer for water-Savings, In collaboration with NIA, PHILRICE, BSWM, ATI and CLSU, November 2004

Jackson MT, Potntial of Water-Saving Technologies in Rice Prodution: An Inventory and Synthesis of Options at the Farm Level, Comprehensive Assessment of Water management in Agriculture, IRRI, September 2002

Jackson MT, Development of Training Course on Water-saving Technologies in Rice Production, Proposal submitted to Asian Development Bank, IRRI, 2002

OPERATION AND MAINTENANCE OF COMMUNAL IRRIGATION SYSTEMS

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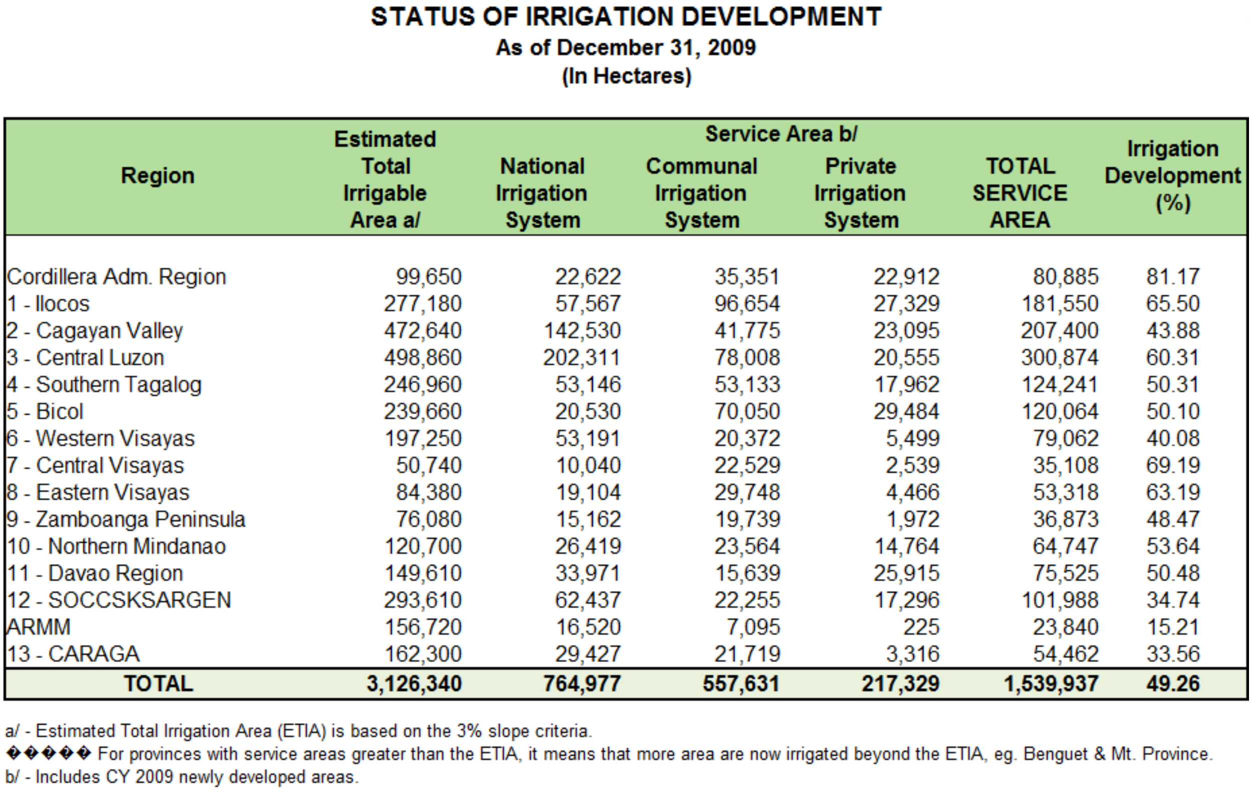
Introduction

Communal Irrigation Systems (CIS) are small-scale schemes, defined as less than 1000 hectares but typically averaging about 100 hectares. They are usually run-off-the-river type dams designed and constructed by the National Irrigation Administration (NIA) with the participation of farmer-beneficiaries through the Irrigator's Associations (IA). The operation and maintenance of CIS is turned over to IAs upon project completion subject to a cost recovery arrangement. The repayment scheme is pre-arranged and acceptable to both NIA and the IA (http://www.nia.gov.ph/activities.php?option=construction).

The Philippines has about 10.3 million ha agricultural lands, of which around 3.1 million ha are considered irrigable. These areas are relatively flat with up to 3% slope and are primarily devoted to rice and corn. As of December 2009, about 1.54 million ha or 49 percent of the potential irrigable areas have been developed for irrigation. Of the total area under irrigation, about 557,630 ha or 36% are under farmer-managed CIS (Fig. 1).



STATUS OF IRRIGATION DEVELOPMENT
As of December 31, 2009
(In Hectares)

Region	Estimated Total Irrigable Area a/	Service Area b/ National Irrigation System	Communal Irrigation System	Private Irrigation System	TOTAL SERVICE AREA	Irrigation Development (%)
Cordillera Adm. Region	99,650	22,622	35,351	22,912	80,885	81.17
1 - Ilocos	277,180	57,567	96,654	27,329	181,550	65.50
2 - Cagayan Valley	472,640	142,530	41,775	23,095	207,400	43.88
3 - Central Luzon	498,860	202,311	78,008	20,555	300,874	60.31
4 - Southern Tagalog	246,960	53,146	53,133	17,962	124,241	50.31
5 - Bicol	239,660	20,530	70,050	29,484	120,064	50.10
6 - Western Visayas	197,250	53,191	20,372	5,499	79,062	40.08
7 - Central Visayas	50,740	10,040	22,529	2,539	35,108	69.19
8 - Eastern Visayas	84,380	19,104	29,748	4,466	53,318	63.19
9 - Zamboanga Peninsula	76,080	15,162	19,739	1,972	36,873	48.47
10 - Northern Mindanao	120,700	26,419	23,564	14,764	64,747	53.64
11 - Davao Region	149,610	33,971	15,639	25,915	75,525	50.48
12 - SOCCSKSARGEN	293,610	62,437	22,255	17,296	101,988	34.74
ARMM	156,720	16,520	7,095	225	23,840	15.21
13 - CARAGA	162,300	29,427	21,719	3,316	54,462	33.56
TOTAL	**3,126,340**	**764,977**	**557,631**	**217,329**	**1,539,937**	**49.26**

a/ - Estimated Total Irrigation Area (ETIA) is based on the 3% slope criteria.
���� For provinces with service areas greater than the ETIA, it means that more area are now irrigated beyond the ETIA, eg. Benguet & Mt. Province.
b/ - Includes CY 2009 newly developed areas.

Figure 1. Status of irrigation development in the Philippines by region as of December 31, 2009 (in Hectares). (http://www.nia.gov.ph/).

Performance of Irrigation Systems

Many irrigation projects perform far below their expectations primarily because of low water use efficiency. Available information indicate irrigation water use efficiencies in the order of 30% to 40% compared to design assumption overall efficiency of 50% or more. The end result is low cropping intensity (less than 130% for Philippines) and very low unit area productivity (David, 2003).

Inequity in the pattern of water distribution causes excess water in some places and deficits in others. Farmers whose lands are near the headgate often take advantage of their location by obtaining more water than the tail-enders, especially when the service is not reliable.

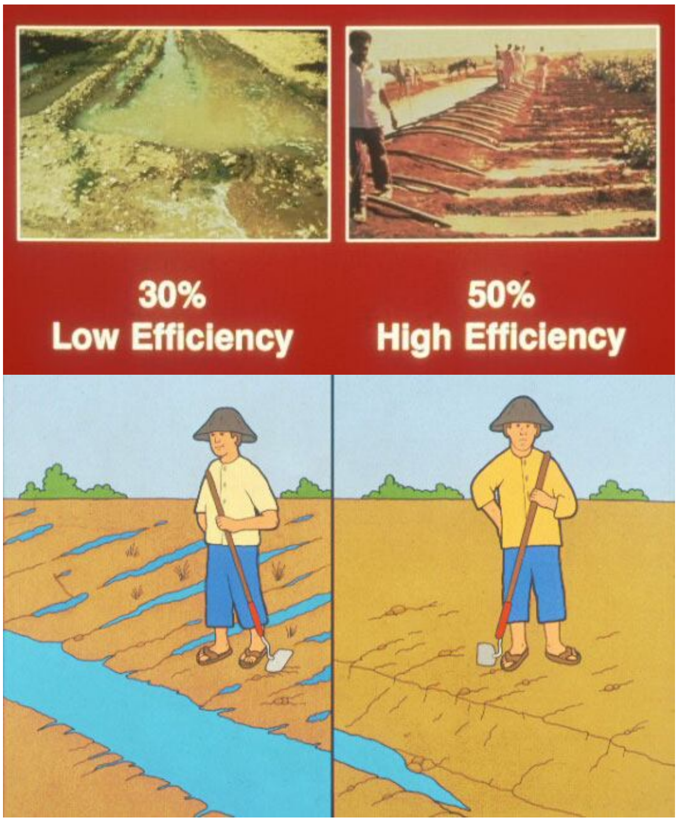


Figure 2. Low efficiency and inequitable water distribution are some causes why many irrigation projects perform below expectations (http://asia-water.org/Water Control/)

Benefits derived from many irrigation projects also fall short of expectations because of the severe deficiencies in irrigation water management. This often result in smaller irrigated areas, in both wet and dry seasons, and lower crop yields. Paddy rice yield, for example, varies between 3 to 4 tons per hectare but under better water management, an average of 5 to 6 tons per hectare may be obtained (http://asia-water.org/Water Control/). The "alternate wet and dry" irrigation technique is also a good example of the policy objective of "more crop with less water."

When water supply is unreliable, farmers are less motivated to manage the irrigation system, participate in operation and maintenance works, and pay water charges. Inadequate funds for maintenance activities aggravate problems and hamper the operation of the system. Inadequate or complete lack of maintenance results in rapid deterioration of the irrigation system, affecting system efficiency and distribution.

What makes irrigation management difficult?

The purpose of an irrigation system is simply to supply water to crops so farmers can obtain higher yields than they could without irrigation. However, an irrigation scheme is difficult to manage because of many reasons (Snellen, 1996). First, it involves two different organizations: one for managing the supply of water to the groups (i.e. NIA to IAs), and another for distributing water within each group (i.e. IA to farmers). Second, irrigation management involves more complicated operations. Irrigation water has to be applied depending on the crop requirement at different growth stages. System managers (usually water tenders or water masters) first have to obtain information on the farmers' water requirements, then draw up a delivery schedule (depending on water supply), adjust the gate settings throughout the scheme, make the deliveries, and then start all over again for the next round of applications. Third, because of the complicated operations there is more likelihood of conflicts. These include those: (a) among farmers within a group of water users; (b) among groups of water users, and; (c) among the groups and the managers of the main system. These conflicts are difficult to resolve. Fourth, obtaining payment from the farmers is difficult. If a farmer do not wish to pay, it is difficult to stop water deliveries to that farmer when water is delivered to a group. Finally, irrigation management is especially difficult if irrigation demand exceeds supply. In an irrigation scheme, the maximum supply is limited by water availability and channel capacities.

Objectives of Irrigation Systems

The first thing needed in an irrigation scheme is people, people working together (Snellen, 1996). In irrigation schemes, the water distributor (i.e. NIA) is a public institution, while the group of farmers (i.e. IAs) receiving the water is private. If the scheme operators depend, wholly or partially, on financing by the government, then there is even a third party involved: the government. The objectives of irrigation systems can be defined from three different perspectives: the farmers, the system operator, and the government.

1. Farmers' objectives: to achieve the maximum possible yields
   - farmers would like to have immediate access to irrigation water
   - to use water whenever they need it, at a sufficient rate, and for as long as they want
2. Government objectives: (a) increase crop or food production
   (b) create employment
   (c) reduce rural poverty
   - the government prefers to spread irrigation benefits over a large group of people but due to high construction cost, limited budget and supply, the irrigated area is less and total freedom in water utilization suffers
3. System Operators' objectives: to manage the scheme in a way that is acceptable to all parties:
   (a) equitable water allocation
   (b) simple operating procedures
   (c) efficient distribution
   - the irrigation system operator may be a government agency (i.e. NIA for National Irrigation Systems) or a farmer association (i.e. IAs for CIS)
   - the operators are caught in the middle: (a) farmers expect them to provide adequate irrigation to increase crop production, (b) the government wants them to serve a large group of people at the lowest possible cost to the government
   - where water resources are limited, as is often the case, the provider must restrain individuals from competing in their own self-interest requiring enforcement of rules governing water distribution

A Service Agreement is needed to reconcile the objectives of the farmers, operator and government, and to create a situation that is acceptable to all. The Service Agreement should specify the following:

- the irrigation services that the operators will provide to the farmers;
- the farmer's contribution - in cash or labor - in return for the irrigation services;
- the methods to check if both parties are fulfilling their agree-upon obligations;
- the action to be taken if any party is remiss in their obligations.

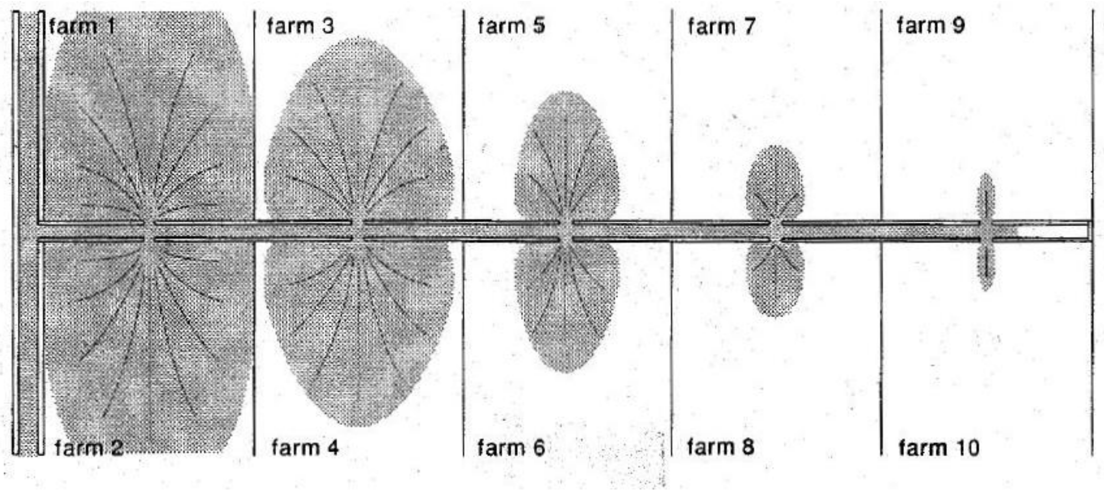
In farmer-managed schemes, a service agreement can be used to describe the arrangements between the individual farmer and the group of farmers who together act as scheme operators. Forming an Irrigator's Association, they assume responsibility for water distribution among farmers, maintenance, collecting irrigation fees from users, and in negotiating with the scheme operators (NIA) on the service agreement. The negotiations could be conducted in a series of meetings attended by an agreed upon number of farmers. The participation of women is very important in drawing up the service agreement. In the negotiation process, the interest of the poor, small-farm owners and tail-end farmers must be included but it should also be balanced with the need for the participation of the more productive farmers. The service agreement should be amenable to adjustments and improvement after every irrigation season.

Operation of Small-sized Irrigation Schemes

In the delivery of irrigation water, the concerns of most farmers are: (a) the timing or predictability of the water delivery; (b) flow rate or how much water is delivered, and: (c) duration of irrigation application. In most surface irrigation systems however, and particularly during the dry season, farmers do not enjoy the flexibility of water delivered on pre-arranged demand.

Irrigation is usually delivered by gravity using open channels because of large flow rates. As such, farmers cannot just open and close their farm turnouts as they wish because if too many farmers located closer to the source are irrigating, the downstream users will receive no water (Fig. 3a). And if farmers stop irrigating, the canal will overtop (Fig. 3b). In an open channel scheme the flow entering the system should equal the sum of the flows delivered to the farms (Fig. 3c).

(a)



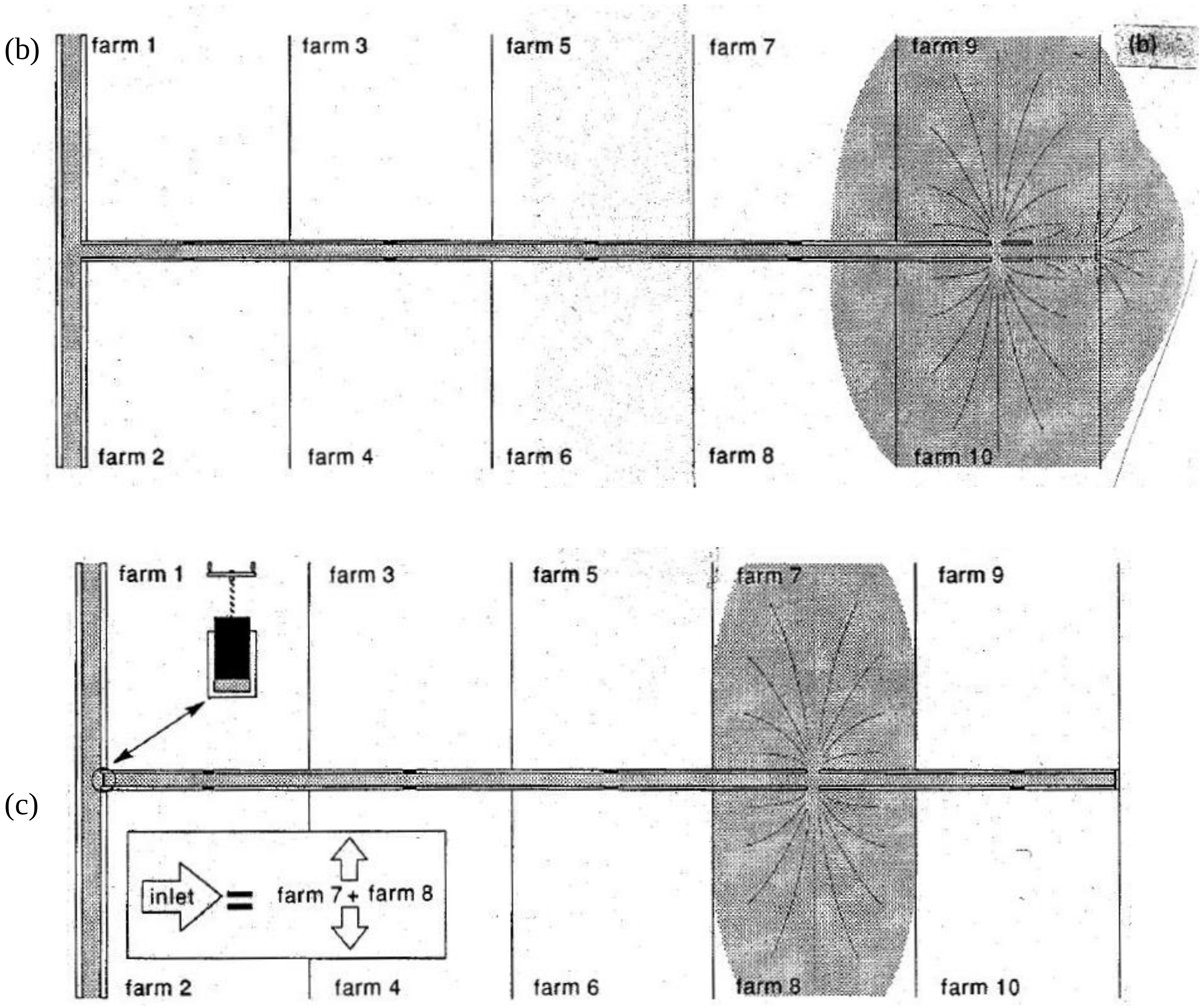


Figure 3. An open canal serving ten farms: (a) Too many farmers located upstream in the scheme are irrigating so that farmers downstream receive no water. (b) If farmers suddenly stop irrigating, the canal will overtop. (c) In an open canal scheme, the flow size entering the scheme must equal the sum of the flow rates delivered to farmers. (Snellen, 1996)

The basic techniques of water distribution include:

(a) supply at will or ‘on demand,’
(b) time sharing or ‘rotation,’ and
(c) flow sharing or ‘partition.’

The first technique is the ideal mode of water delivery from a farmer’s viewpoint. But farmers are generally free to use water at will only during the rainy season or in areas where water supplies are abundant. The last two techniques are water sharing schemes which are adapted during periods of low flows in rivers or in areas with limited water supplies.

In the time sharing technique, the full canal discharge is delivered to a farm or an irrigation sector at a fixed length of time (e.g. 24 hrs) depending on the schedule agreed upon in the service agreement. The flow is then diverted to the next sector or farm for the same duration until every farm or sector in turn received their share in the rotation and the process is repeated. The duration of irrigation delivery should be chosen to meet both the crop water requirement and the convenience of the farmers. This method requires action from the operators to direct the canal flow to the farm that is scheduled to receive irrigation water. This is the most common distribution technique applied in IA-operated CIS.

In the flow sharing or proportional delivery method, every farm or sector receives an equal share of the canal discharge. This method would require a flow dividing structure such as a proportional division box. On the other hand, this method does not need any action by operators for regulating the flow. In practice, flow sharing and time sharing are often combined together within the same scheme.

Different operational procedures should be prescribed for three levels of water availability: (a) abundant, (b) ordinary low water, and (c) extraordinary drought. In times of water abundance, the farmers are free to use water at will and the only problems during these periods are leaching and drainage. During annual dry season periods, water sharing schemes can be applied. However, the IA's should also be prepared during extraordinary dry spells (e.g. El Niño).

In distributing water to tertiary units, one method to reduce cost is to let a group of farmers share a common outlet (Fig. 4). This also reduces the operational tasks of the scheme operators. Water distribution should be made through a single canal or canal system with each farmer creating an opening in his plot to let water in. The practice of distributing water from plot to plot should be discouraged as this entails a lot of seepage, percolation and evaporation losses.

Water measurement, at least for one tertiary unit, helps allocate equitable water distribution and provides information needed to achieve the best use of the irrigation water applied. Unfortunately, measurement of flow rate is not performed in most CIS. If it is done at all, this is performed only at the headgates and is usually rough estimates.

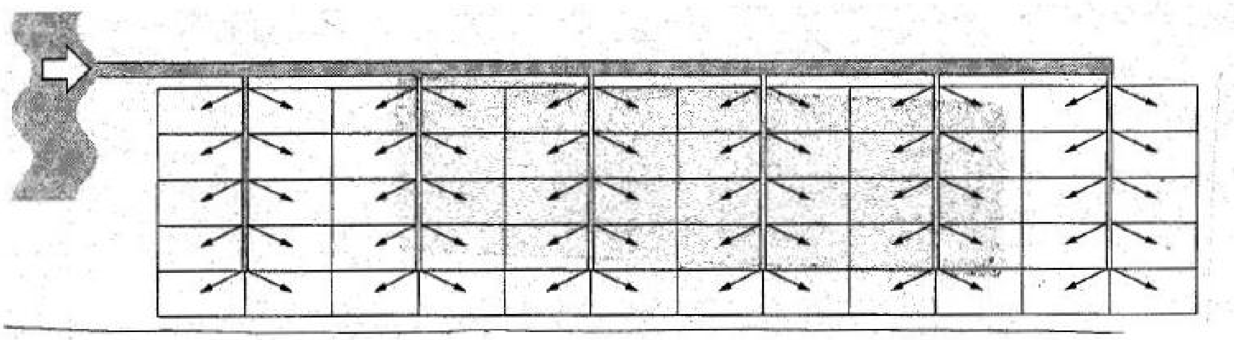


Figure 4. Layout of an irrigation scheme that uses a common outlet for a group of farmers (Snellen, 1996)

Irrigation Planning

Irrigation planning involves making decisions on the cropping pattern for the coming irrigation season. It considers the farmers preference, including what crops to grow (most CIS are used for rice monoculture). There are problems, however, since: (a) the farmer does not know the total water needs of the scheme and the total water resources available to the system, and (b) the farmer does not control the allocation and distribution of irrigation water in the system. If water supply is limiting, some restrictions as previously stated may be applied. In the case of abnormal weather conditions (e.g. El Niño), both water resources and irrigation needs during the irrigation season can be different from what was expected.

Farms should be grouped into tertiary unit and each unit draws up and submits the cropping pattern to the system management. The operator then calculates the expected irrigation needs for each tertiary unit and for the whole system. The cropping patterns are acceptable if:

- the expected operational irrigation need for each unit does not exceed the discharge that can be delivered from the offtake
- the expected operational need for the scheme does not exceed the available water supply

In order to match irrigation needs with irrigation supply, the scheme managers may propose a number of strategies. They could advise to:

- set a maximum area that can be cultivated with crops that have a high irrigation need (e.g. rice): for example, not more than 50% of the area in each tertiary unit may be planted with rice;
- stagger the growing season, in order to reduce its peak water requirement;
- concentrate the planting period within each tertiary unit and stagger planting periods at system level; in this way the peak water requirements of the tertiary units will occur oneafter another, instead of simultaneously;
- restrict the number of tertiary units with rice

Irrigation Scheduling

Irrigation scheduling is the activity of making the program for the coming week (or 10 days, 2 weeks, one month) of water distribution in the scheme during that period. The two main reasons for preparing such a program:

(a) farmers wants to know when they will receive irrigation water (= timing), how much (= flow rate) and for how long (= duration)
(b) operators need to know when and how to adjust gate settings

Irrigation applications are intended to meet the water requirements of the crops cultivated in the system. For an individual farm, the irrigation requirement for the next week depends on:

(a) the crops grown, and the area and growth stage of each crop
(b) the moisture conditions in each field
(c) the weather conditions expected for the coming week

Many decisions at the farm must be made without accurate knowledge of the future. Decisions on what crops to grow, when to plant, how much and when to apply fertilizers and other agro-chemicals are all made on the basis of the farmers' expectations and previous experience with rainfall, sunshine, pests and diseases, crop yields and market-prices.

Maintenance of Small-sized Irrigation Schemes

Many irrigation systems do not provide adequate service to farmers because gates can no longer move due to rust or because parts are missing or broken, canal sections have collapsed or are full of silt, water level gauges have disappeared, etc. All of the above are the result of poor maintenance (Snellen, 1996).

Maintenance activities for an irrigation scheme fall into three categories

(a) Routine maintenance

- greasing gates
- removing vegetation from embankments, canals and drains;
- removing silt from canals, drains and structures

Other routine maintenance that requires skill

- repairs to gates and measuring structures
- repainting of steel structures
- installation of water level gauges
- maintenance and small repairs of pumps and engines

Larger routine maintenance - usually done between irrigation seasons, when the canals are drained

- major repair or replacement of gates, pumps, and engines
- large-scale silt clearance from canals and drains
- large-scale maintenance of roads and embankments

(b) Emergency works- require immediate and joint action by irrigation staff and farmers, to prevent or reduce the effects of unexpected events

- breach or overtopping of canal embankment or river dike, causing flooding
- critical failure of pumps or headworks, causing interruption of irrigation water supply
- natural disasters such as floods, earthquakes or typhoons

(c) System improvement

- alterations in newly constructed schemes
- gradual system development and improvement
- adapting to change

Managing maintenance activities is important:

- to keep the scheme in good operating condition so that it will provide uninterrupted service;
- to extend the useful life of the system;
- to achieve the above at the lowest possible cost

Maintenance activities should be included in the service agreement. These may include:

- a description and timing of planned maintenance activities
- a specification of items for which repair services will be provided, procedures for requesting repair services and maximum time period within which repair services will be provided
- the method for calculating costs of services
- the bills for services, the time period within which bills must be paid and the surcharge applicable for bills in arrears

- the compensation payable if the services specified in the agreement are not provided
- the authority that will arbitrate in the case of disputes.

References

David, W.P. 2003. Averting the Water Crisis in Agriculture: Policy and Program Framework for Irrigation Development in the Philippines. The University of the Philippines Press and Asia Pacific Policy Center. 168 pp.

Lecture Notes on AENG 41. Irrigation and Drainage Engineering I. Land and Water Resources Div., IAE, CEAT. UP Los Baños.

Lecture Notes on AENG 145. Water Control Structures. Land and Water Resources Div., IAE, CEAT. UP Los Baños.

Snellen, W.B. 1996. Irrigation Water Management. Training Manual No. 10: Irrigation Scheme Operation and Maintenance. ILRI. FAO. 55 pp.

http://asia-water.org/Water Control/

http://www.nia.gov.ph/activities.php?option=construction

CLIMATE FORECAST APPLICATION FOR EFFECTIVE WATER MANAGEMENT

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Introduction

Climate change is expected to intensify the many problems facing agriculture in our country. The dry seasons have become more prolonged and intense while the rainy seasons have brought widespread flooding and induced pest and diseases. Most vulnerable are rainfed areas and those relying on small rivers and streams for irrigation. Improved control of water resources is a fundamental method for mitigating the impacts of climate variability. Methods range from small scale on-farm and community based measures with local control to large scale infrastructure with institutionalized and governmental control (Brown and Hansen, 2008).

An extreme climatologic event that poses a major threat to rice-based agriculture is the El Niño phenomenon. Strong tropical cyclones (typhoons) and prolonged wet season (i.e. due to La Niña phenomenon) can also cause damage to crops, but rice being more tolerable to flooding is less vulnerable on these conditions. El Niño-induced droughts, on the other hand, are the primary causes of rice production instability in the country as they can drastically reduce rice yield and production. The coping mechanisms implemented by the government have not been very effective. For example, prior to the 1997-98 El Niño episode, the government spent billions for irrigation development to cushion the adverse effect of the phenomenon on agricultural production but at the end, the government still has to import 2.7 million metric ton of rice or about 27% of its annual requirement (David and Delos Reyes, M., 2007).

It is important to understand and be able to predict the effect of El Nino on rice production to able to put in place effective coping mechanisms, not only at the national level but also at the more vulnerable rural farming communities. Farmers and the Irrigators Association (IAs) managing small-scale irrigation systems often do not have the information or are informed too late about such extreme events to be able to respond in a favorable manner. They should put in place a different water management procedure that is applicable during extraordinary drought. The IAs should be made aware of early warning systems that would enhance their coping capacities and support timelier and better coordinated response to such climatic extremes.

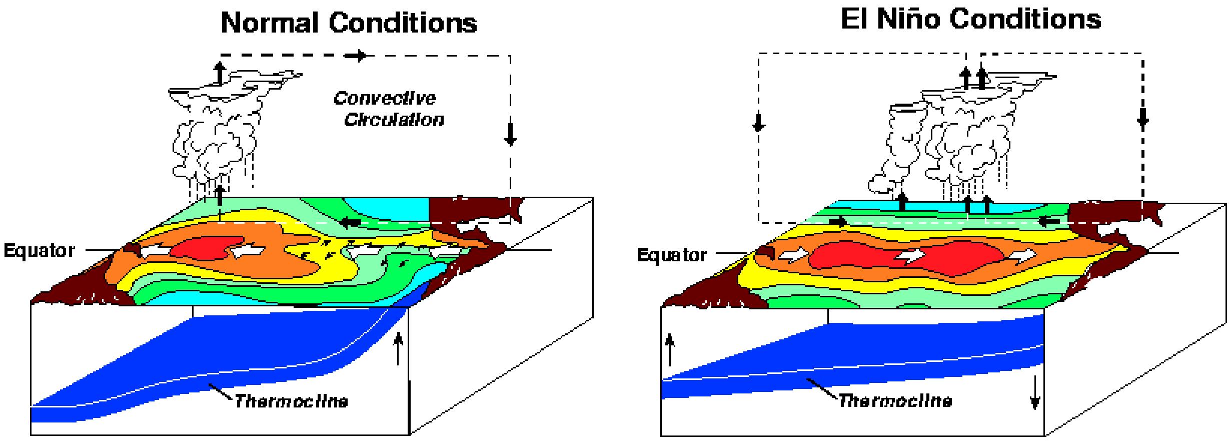
El Niño Southern Oscillation (ENSO)

El Niño is a recurrent large-scale ocean-warming that develops over the equatorial Pacific resulting to prolonged drought in some areas of the globe, and heavy rains and storms in others. El Niño, Spanish for “the little boy” and refers to the child Jesus was the term given by Peruvian fishermen to an episode that is usually noticed around Christmas, when they caught a lot of fishes near the coast. During that period, a warm current actually migrated to the eastern Pacific region forcing the fishes to migrate towards the coast.

The National Oceanic and Atmospheric Administration (NOAA) define El Niño as a phenomenon in the equatorial Pacific Ocean characterized by a positive sea surface temperature (SST) departure from normal (1971 –2000 base period) in the Niño 3.4 region (long. 1200W-1700W and lat. 50N –50S) greater than or equal to 0.5°C averaged over three consecutive months (http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html).

Under normal condition (Fig. 1a) in the Pacific Ocean during the first half of the year, there is an area of high atmospheric pressure in the southeastern Pacific (represented by Tahiti) and an area of low atmospheric pressure on the western side over the Philippines, Indonesia and Australia (represented by Darwin). The pressure difference drives the trade winds from east to west across the tropical Pacific. These winds pick up water as they go, raising the sea level in the western Pacific by about 0.5 meter. They also depress the thermocline to a depth of about 200 meters.

During El Niño (Fig. 1b), warm sea surface temperatures (SST) cause the atmospheric pressure to become much lower than average in Tahiti and much higher than average in Darwin. The pressure difference decreases, thus upsetting the normal wind circulation. This change in pressure patterns is called the Southern Oscillation (SO). Without the usual cross-ocean pressure differential to drive them far westward, the trade winds weaken and do not reach the shores of the western Pacific countries. In the event of a strong warm episode, they even reverse in direction, causing the Pacific trade winds to surge back eastward.



(a) (b)

Figure 1. (a) Normal condition and (b) El Niño conditions (http://www.pmel.noaa.gov/tao/elnino/nino_normal.html#nino)

Effect of El Niño on Spatial and Temporal Distribution of Rainfall in the Philippines

In the Philippines, El Niño usually appears every 2 to 7 years. For the past 55 years, there were 15 El Niño episodes: 1957-58, 1963-64, 1965-66, 1969-70, 1972-73, 1976-77, 1977-78, 1982-83, 1986-87, 1991-92, 1993-94, 1995, 1997-98, 2002-2004 and 2009-2010. The strongest recorded were the 1982-1983 and 1997-1998 episodes.

To gain insight on the effect of El Niño on the spatial and temporal distribution patterns of Philippine rainfall, David and de los Reyes, M. (2007) analyzed the monthly rainfall in about 60 synoptic stations all over the Philippines during the strong El Niño episodes 1982-83, 1986-88 and 1997-98. Their results show that the impact on Philippine rainfall was initially felt 4 to 5 months after the development of a Pacific-wide warm episode. The data also suggest that the stronger the warm episode is (larger SST abnormality) the earlier is the onset of El Niño effects on Philippine rainfall. The effect will last as long as the warm episode over the Pacific exists. In two of the strong episodes, El Niño conditions persisted 1 to 2 months after SST returned to normal. In the 3 episodes, abnormal rainfall condition lasted from 11 to 16 months.

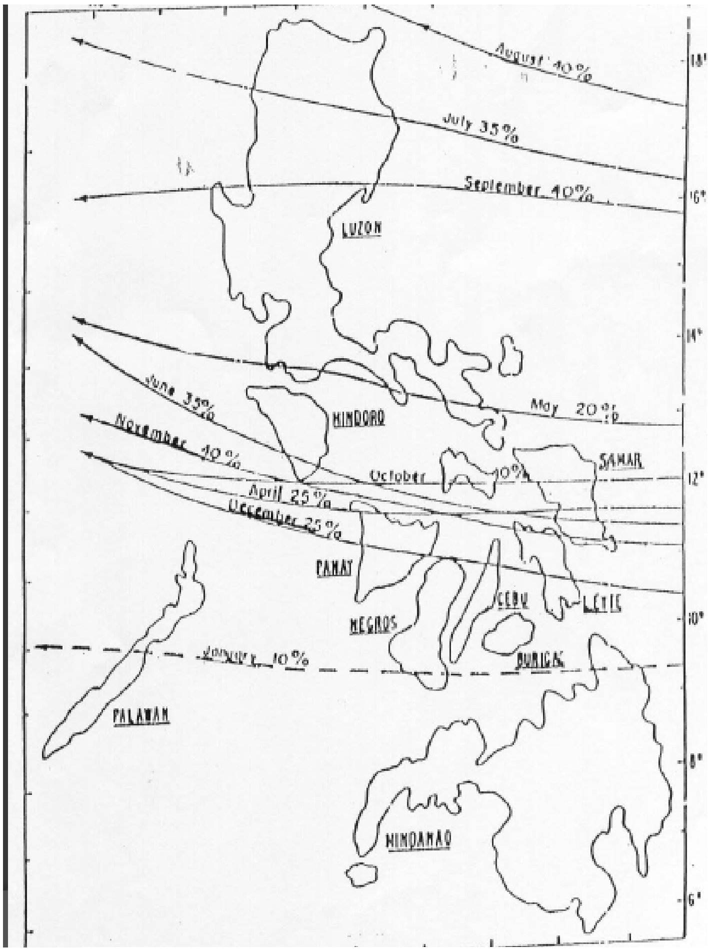


Figure 2. Mean monthly tracks and percentage of tropical cyclones crossing the Philippines (source: PAGASA)

The mean monthly tracks and percentage of tropical cyclones that crossed the Philippines are shown in Fig. 2. Their tracks were all in westerly or northwesterly direction. During the 1997-98 strong El Niño episode, however, very few typhoons crossed the Philippines. Most of them failed to cross the country and instead veered to the northeast towards Japan or back to the Pacific Ocean (Fig. 2).

David and de los Reyes, R. (2006) also studied seven El Niño events (1997-98, 1994-95, 1990-93, 1986-88, 1982-83, 1977-78, and 1972-73) to determine their effects on rainfall and tropical cyclones. Results showed that the effect of a warm episode on monthly rainfall and tropical cyclones depended on the intensity, location, area coverage, duration and time of occurrence of the episode.

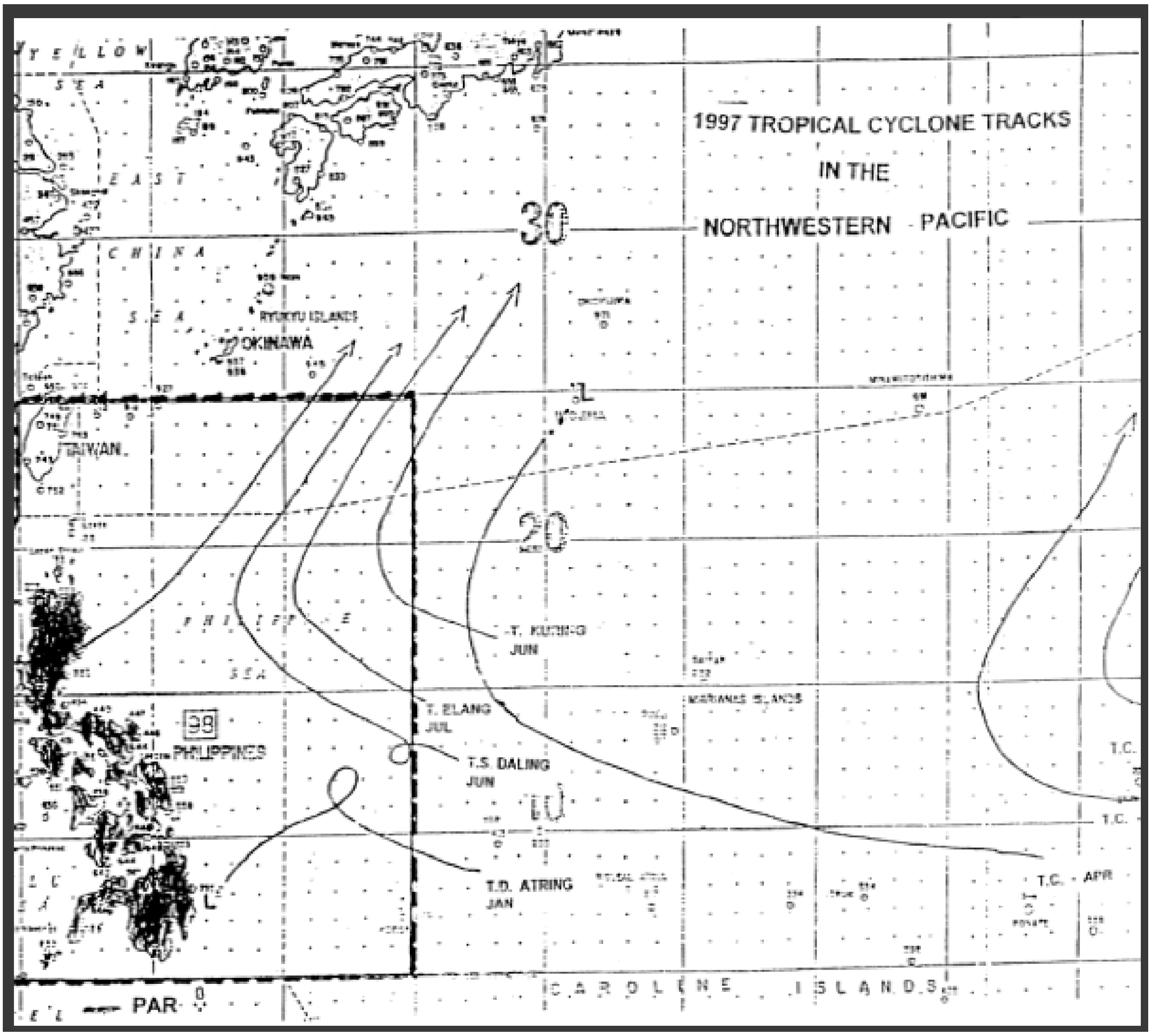


Figure 3. Tropical cyclone tracks towards the Philippines in 1997: (source: PAGASA)

Some general patterns on the effects of the phenomenon were observed from the study. The effect of El Niño on Philippine rainfall is initially felt 3 to 5 months after the development of a warm episode in the tropical Pacific. Strong El Niño events took 5 to 8 months to cover the whole country with drought, while weak-to moderate El Niño events required only 1 to 4 months. Recovery from the effect of El Niño, on the other hand, starts when the SST in central and eastern tropical Pacific returned to normal conditions. Recovery always starts in Mindanao and moves in a northeasterly direction. Full recovery from the effect of El Niño was observed 3 to 4 months later during strong events and 5 months up to 1-year during weak-to-moderate events. These results suggest that strong El Niño events have short but intense effect while weak-to-moderate events have longer but milder effect on Philippine rainfall.

During the peak of strong events, reductions of more than 50% of the monthly rainfall were experienced in most parts of the country because strong El Niño events suppressed tropical cyclone activity. Weak-to-moderate El Niño events did not totally suppressed but shifted the tracks of tropical cyclones towards the northeast. During strong El Niño events, about 14 tropical cyclones per year entered the Philippine area of responsibility (PAR). This is 29% lower than the average number of tropical cyclones that entered the PAR per year.

Effect of El Niño on Rice Production

David and de los Reyes (200_) also studied the effects of El Niño on dry- and wet-season rice production. In the 4 strong El Niño episodes studied, which severely affected 5 dry season crops, the rice yield decreased between 14.1% to 29.3%, or an average loss of about 21.7%. On the other hand, the 3 moderate El Niño episodes that affected 3 dry season crops reduced the total rice production by just 5.2%. Two weak episodes affecting a single dry season crop have minimal effect on the production. In all other episodes included in the study, the rice yield even increased by 3%, which may be attributed to increased solar radiation

In terms of wet-season rice production, 2 strong El Niño episodes adversely affected rice production in 4 wet seasons, with the yield reduction ranging from 5.7 to 27.2%, or averaging at 12.4%. A weak El Niño episode, however, could be beneficial to rice production. A single moderate episode decreased the total rice production of 1 wet season by about 9.0%. Two weak episodes that occurred during 3 wet cropping seasons increased rice production by an average of about 8.9%. These yield increases during the wet season crops may be attributed to less flood damages and higher level of incident solar radiation.

Effect of El Niño on Water Availability to Crops

A projected El Niño-induced drought may usher in the following hydrologic side effects that affect agricultural water supply sources. The extent of these effects will depend on the duration and intensity of the drought. In chronological order, they are:

(d) Rainfed areas – will be affected first; Upland areas planted to annual food crops that are shallow rooted will be worst hit.
(e) Small streams and creeks – Dry season dependable low will be greatly reduced, or will dry up completely because they have smaller catchment areas and are not deep enough to be replenished by shallow aquifers
(f) Small run-off-the-river irrigation systems – Although designed for 80% dependable flows, they can actually irrigate only about 54% of their service areas during the regular dry season. With El Niño, actual stream flow will be much less, reducing actual irrigated or command areas. This includes many CIS
(g) Small water impounding irrigation systems, small farm reservoirs or farm ponds – Many of these will dry-up since their inflows come mainly from run-off from rainfall.
(h) Large rivers – flow will be reduced, except in large deep rivers with reliable baseflows. In a prolonged drought, command areas for many NIS and CIS will be considerably reduced.
(i) Large reservoirs – The active storage will be greatly decrease due to increased pressure to release more water with increased losses due to percolation and evapotranspiration.

(j) Aquifers – Groundwater levels of unconfined shallow aquifers will start to decline, followed by those of confined shallow aquifers and eventually, those of deep aquifers.

Conclusion

Despite government investments in agricultural water management, and the best use of climate information, extreme climate events such as the El Niño phenomenon will test the ability of farmers and IAs to cope. These events can have damaging impacts, not only on rice production, but on rural development efforts in general. Enhancing the capability of farmers and water users group through early warning and response systems can help mitigate the impact of these extreme events. Given enough warning time, an effective water management procedure can be planned and adapted for the whole CIS.

References

Brown, C. and Hansen, J. 2008. Agricultural Water Management and Climate Risk. Report to the Bill and Melinda Gates Foundation. IRI Tech. Rep. No. 08-01. International Research Institute for Climate and Society, Palisades, New York, USA. 19 pp.

David, W.P. and Delos Reyes, M., 2007. El Niño: Its Nature, Effect on Philippine Rainfall and Rice Production. Lecture notes on AE 243.

Delos Reyes, R and David, W.P. 2006. Spatial and temporal effects of El Niño on Philippine rainfall. The Philippine Agricultural Scientist 89 (4), 296-308.

http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

http://www.pmel.noaa.gov/tao/ elnino/nino_normal.html#nino

ASSESSING THE FEASIBILITY OF ALTERNATIVE WATER SUPPLY SOURCES

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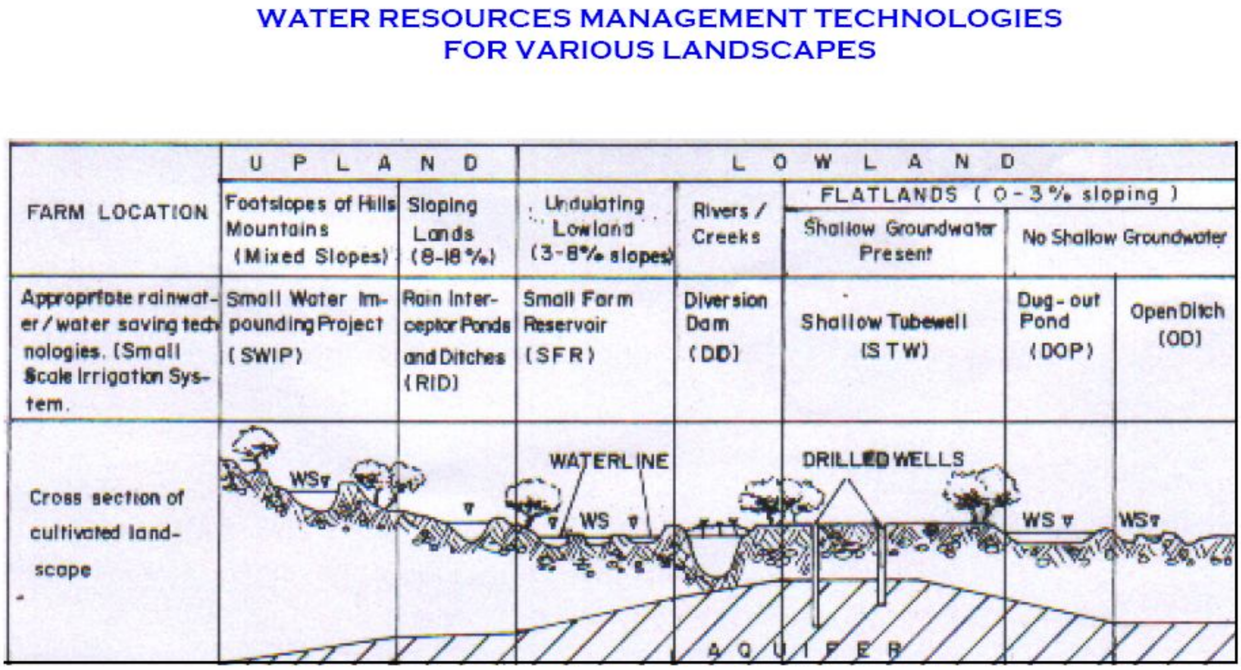
Introduction

The poor performance of gravity irrigation systems, both national (NIS) and communal (CIS), have been attributed to several factors including: (a) inadequate database for planning; (b) inadequate institutional capacity and mechanisms for development; (c) design mistakes; (d) poor quality of construction; (e) inadequate and fragmented support services for irrigated-agriculture, and; (f) complexity of operation including the socio-economic and institutional management (David, 2003). Measures to improve the performance of irrigation systems include rehabilitation of existing facilities, completion of on-going projects and construction of new facilities. The trend now is to focus on smaller systems which are more efficient, easy to manage, amenable to privatization, cheaper to construct and have shorter gestation period.

Presented here are some of the alternative water management technologies that Irrigators Associations (IAs) may use to supplement irrigation in CIS, especially during prolonged dry seasons and extraordinary droughts. Depending on the farm location (Fig. 1), IAs may opt for small water impounding projects (SWIP), shallow tubewells (STW) or low-lift pumps (LLP), small farm reservoir (SFR) or any of the small water harvesting techniques such as rain-interceptor ponds (RIP) dug-out ponds (DOP) and open ditches (OD).



WATER RESOURCES MANAGEMENT TECHNOLOGIES
FOR VARIOUS LANDSCAPES

	UPLAND		LOWLAND				
					FLATLANDS (0-3% sloping)		
FARM LOCATION	Footslopes of Hills Mountains (Mixed Slopes)	Sloping Lands (8-18%)	Undulating Lowland (3-8% slopes)	Rivers / Creeks	Shallow Groundwater Present	No Shallow Groundwater	
Appropriate rainwater / water saving technologies. (Small Scale Irrigation System.	Small Water Impounding Project (SWIP)	Rain Interceptor Ponds and Ditches (RID)	Small Farm Reservoir (SFR)	Diversion Dam (DD)	Shallow Tubewell (STW)	Dug-out Pond (DOP)	Open Ditch (OD)

Figure 1. Water resources management technologies for various landscapes (BSWM, 2002)

Shallow Tubewells (STW)

Much of the growth in irrigated areas in recent years has come from tubewells. STWs are pipes installed in the ground for the purpose of bringing groundwater into the soil surface (Fig. 2). They are usually set at a depth of less than 20m and extracts water from shallow aquifers by suction lifting. STW pipes are usually from 1.25 to 6 inches (32 to 152mm) in diameter, with the 4-inch (102mm) tubewell as the most common for irrigation purposes. The pump is set at the ground surface and is usually powered by single cylinder diesel or gas engines and electric motors. For a 4" pipe, 7 to 8 Hp engines are common (Fig. 3).

Figure 2. A typical shallow tubewell (STW).

The National Water Resources Board (NWRB) in their rapid appraisals of our groundwater resources estimated that the Philippines have about 5.1 million hectares of shallow well area. This vast potential STW areas are mostly located in rice and corn growing alluvial plains, which could be tapped to irrigate new areas or supplement the water supplies of existing CIS command areas. Aside from the extensive shallow well area, STWs are cost-effective with low investment cost from P5,000 to P30,000 per hectare. It is simple to operate and can be controlled by individual or a group of up to 3 farmers, promoting farmer empowerment. It is amenable to privatization, requiring no O&M subsidy from the government, and thus, sustainable. It has a short gestation period requiring only a few days to install and one or two weeks to be developed. The pump prime mover or the engine, which constitutes about 2/3 of the cost of an STW can be used to power hand tractors, threshers, trailers (kuliglig) and other farm machineries.

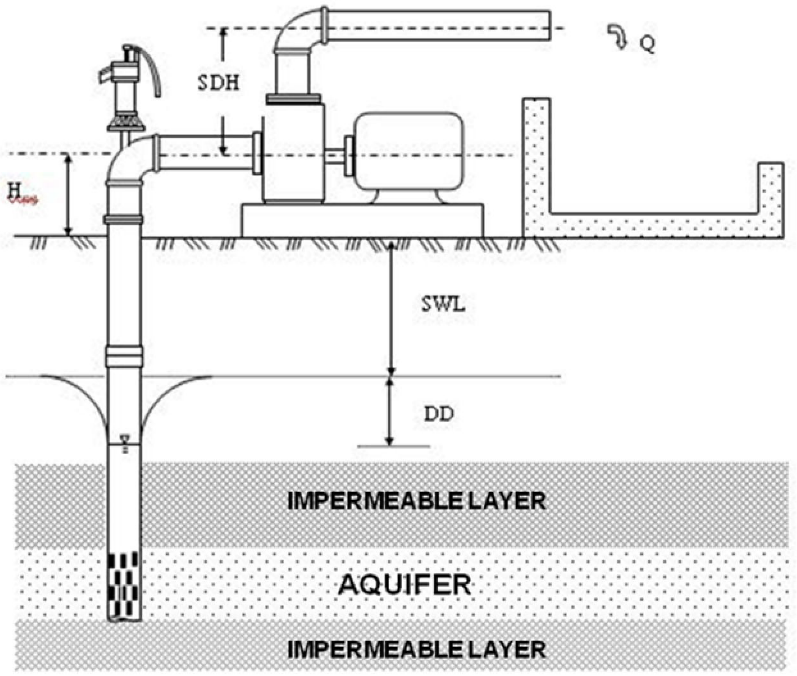


Figure 3. Schematic diagram of a shallow tubewell (STW) system setup.

There are still some constraints and disadvantages in using STWs. There are inadequate information on shallow aquifer properties that are required for the proper design, drilling and development of STWs. There is also inadequate number of technically capable well drillers in many areas. And in most cases they lack the proper well drilling equipment and technologies especially for difficult geologic formations.

These constraints have been addressed through trainings of agricultural technicians and drillers down to the local levels.

The Department of Agriculture (DA) through the Regional Field Units (RFUs) implemented a STW credit scheme where farmers can avail of loans of up to around PhP 60,000 for the construction of STWs in his farm. It is interest-free and payable in 5 years (10 installments or 1 payment per cropping season assuming 2 cropping season per year). The National Irrigation Administration (NIA) also implemented its own STW credit scheme where the farmers only pay 30% of the installation cost in 2 years. These schemes spearheaded the growth of privately-owned STWs in the country and are largely responsible for the growth of irrigated areas.

The country is also blessed with many natural waterways which are good sources of water for small portable low-lift pumps (LLPs). In some CIS where the dependable flow in the river cannot sustain the design command area or that the river surface is too deep to be raised by a weir, LLPs can be used to pump water to the farm. LLPs are cost-effective with low investment cost of from PhP 3000 to 8000 per ha. Certain types of pumps (e.g. axial flow pumps) are also manufactured locally. Together with the STWs, these cost-effective, efficient, farmer-controlled minor irrigation technologies offer the best growth opportunities for Philippine agriculture in the short- and medium-terms (David, 2003).

Small Water Impounding Projects (SWIP)

A SWIP is an earth dam structure built across a narrow depression or valley to harvest and store rainfall and run-off for multiple uses (Fig. 4). It has a maximum height of 30 meters. SWIPS are designed and constructed by the Bureau of Soils and Water Management (BSWM) and RFUs in coordination with NIA and local government units (LGUs) (BSWM, 2002).

Service areas of SWIPs range from 20 to 150 ha per project with an average of 50 ha per project. The average investment cost is about PhP 150,000/ha (2008), which is still prohibitive. As of December 2008, there are about 384 SWIPs in the country serving 22,083 ha with 16,250 farmer-beneficiaries (http://www.searca.org/web/adss/2009/handouts/ADSS_Cabezon_27Jan 2009. pdf).

Among the uses and benefits of SWIP are: (a) it ensure crop intensification and diversification; (b) it ensure improved farm income; (c) it minimize soil erosion and nutrient losses and prevent flooding of low-lying areas; (d) it can be used as local recreation site and area for soil and water technology researches, and (e) it recharge the groundwater.

Figure 4. A typical small water impounding project (SWIP).

(http://www.searca.org/web/adss/2009/handouts/ADSS_Cabezon_27Jan2009.pdf)

Priority beneficiaries of the BSWM are organized farmers association having areas with no problems in "right of way" and other social problems, and are capable and willing to shoulder full cost of operations and maintenance. Interested IAs may request assistance or submit written resolutions to the LGUs or BSWM.

Small Farm Reservoirs (SFR)

A Small Farm Reservoir is a water impounding structure with a maximum embankment height of 4m and average pond area of 1,500 square meters (Fig. 5). It serves limited areas no more than 2 hectares and is designed to become an integral part of individual rainfed farms with catchment area not exceeding 10 hectares (BSWM, 2002). It offers the same uses and benefits as the SWIP but it is less capital intensive and easier to construct and maintain. It also empowers farmer cooperation and production capability. Smaller scale storage offers the benefit of more local control and less externalities in terms of submerged area.

Figure 5. A typical small farm reservoir (SFR) (BSWM, 2002).

Priority beneficiaries are individual farmers with no tenurial problem who are willing to shoulder part of construction cost in excess of PhP 10,000 subsidy from BSWM. They should also be willing to shoulder the full cost of operation and maintenance and adopt appropriate production technologies. Interested IAs may request assistance or submit written resolutions to the LGUs or BSWM.

The basic components of a SFR is shown in Fig. 6. Different types of SFR depending on farm configuration are shown in Fig. 7. They can be dugout ponds, rectangular balanced excavations, semi-circular embankments or straight embankments.

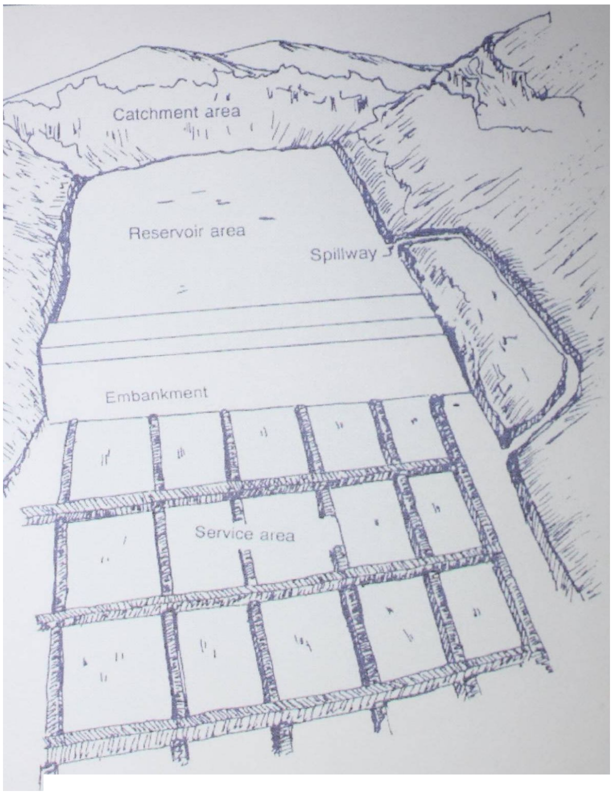


Figure 6. Basic components of a SFR (BSWM, 2002).

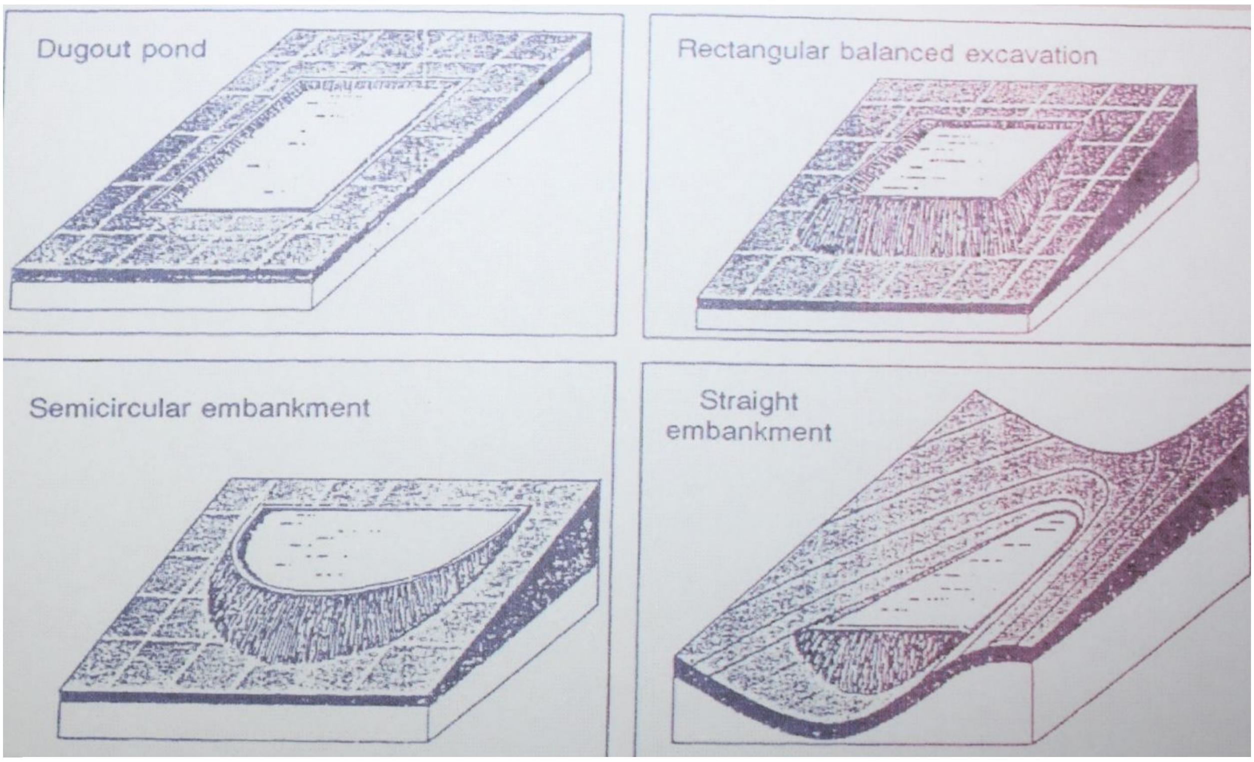


Figure 7. Different types of SFR based on farm configuration (BSWM, 2002).

Other Small Scale Surface Water Harvesting Techniques

1. Dug-out Pond (Fig. 8) – most suited to nearly level or flat areas. A reservoir is constructed by excavating the earth leaving a storage space that can be filled with water from rainfall and run-off. Water can be stored at higher level than the service area where obstruction of water can be done through a siphon or by placing PVC pipes (1" - 2" dia.) at the embankment to allow discharge by gravity. When water stored reach below ground level, pumping is required to draw out water. The maximum height of embankment is 3m.

2. Open Ditch (Fig. 9) – is a system of earth canal established across flatlands with no shallow groundwater. It collects or harvests rainwater during rainy season for storage in the subsoils which is consequently used for dry season crops. Its depth of excavation must not go beyond the permeable layer. A 0.5 x 1.0m ditch is recommended.

Figure 8. Dug-out Pond (BSWM, 2002).

3. Rain Interceptor Pond or Ditch (Fig. 10) – a soil and water conservation innovative technology designed to trap and store run-off and rainfall that cause soil erosion and consequently have adverse impacts to agriculture production. RIDs are established in sloping lands (8-18%) along the contour with a capacity that would allow minimum drain but maximum storage for crop utilization. Maximum height of RID embankment is 3.5 m, established every 50 m of the slope.

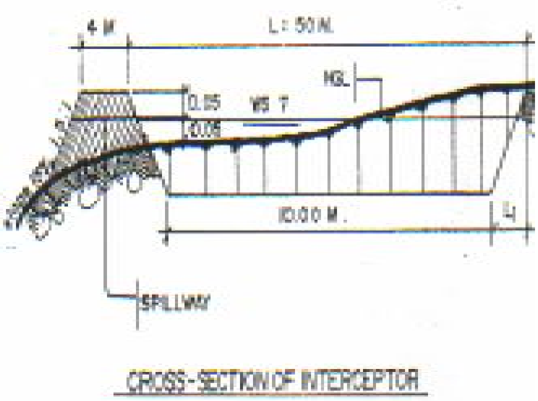


Figure 9. Open Ditch (BSWM, 2002).

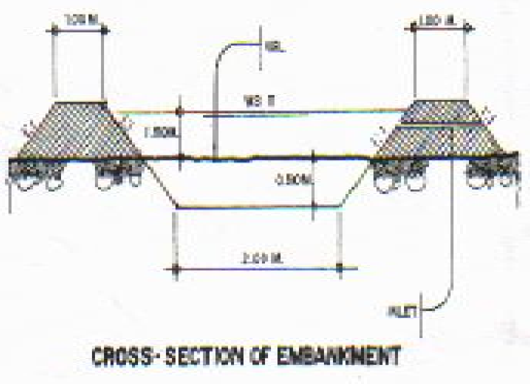


Figure 10. Rain Interceptor Pond or Ditch (BSWM, 2002).

References

Bureau of Soils and Water Management. 2002. Primer on Water Resources Management Technologies. BSWM, Elliptical Road, Corner Visayas Avenue, Diliman, Quezon City.

David, W.P. 2003. Averting the Water Crisis in Agriculture: Policy and Program Framework for Irrigation Development in the Philippines. The University of the Philippines Press and Asia Pacific Policy Center. 168 pp.

http://www.searca.org/web/adss/2009/handouts/ADSS_Cabezon_27Jan2009.pdf