PROGRESS REPORT*

ON THE

ROCKEFELLER FOUNDATION - FUNDED
IIMI-IRRI COLLABORATIVE PROJECT

ON

PROBLEMS OF IRRIGATION MANAGEMENT FOR
RICE-BASED FARMING SYSTEMS
(As of December 1988)

July 1989
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
DIGANA VILLAGE, VIA KANDY

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PROGRESS REPORT
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BACKGROUND

Irrigation remains a major strategy of developing countries to support agricultural production. However, the attainment of near self-sufficiency in rice in a number of countries in Asia and its low world price have reduced the economic returns from irrigated ricelands. This problem could be addressed by: (1) increasing the economic yields of rice; (2) increasing the area served by scarce water resources through more effective and efficient irrigation system management; and (3) introducing crops of higher value than rice into the irrigated rice farming system. Taking these into consideration, the Rockefeller Foundation provided a grant effective 1 July 1987 to the International Irrigation Management Institute (IIMI) and the International Rice Research Institute (IRRI) to undertake a collaborative research on irrigation management for rice-based farming systems.

The IIMI-IRRI collaborative project has identified six broad objectives:

1. To characterize the factors which influence the options for changes in rice-based farming systems, and to identify the more important options in selected geographic locations;

2. To determine the degree to which different levels of irrigation system performance influence the ability to incorporate changes in the farming systems effectively;

3. To develop efficient and economical methods for managing irrigation water delivery and use of post-rice residual water for rice-based systems in which non-rice crops are grown, with special reference to implications for agronomic practice and for institutional performance and change;

4. To transmit and interpret the research findings to agricultural and irrigation system managers, planners and policymakers to encourage informed and better decision-making;

5. To enhance the development of trained professionals in the area of irrigation problems through provision of graduate research opportunities; and

6. To provide an opportunity for IRRI and IIMI staff to interact in a variety of collaborative activities which would permit the development of an effective and mutually supportive long-term relationship.

The collaborative activities started with the first of a series of discussions at IRRI on April 9-10, 1987 among scientists and administrators from both institutions. Beginning early October 1987, consultation meetings were held with national agencies in the Philippines and in Indonesia. Because of the unstable political situation in Bangladesh, limited consultation could only take place in late January 1988. Scientific staff from IIMI and IRRI met jointly with officers of local irrigation, agricultural, research, and planning agencies and universities in identifying the research areas and strategy for the project's implementation.

This report covers primarily the substantive aspect of the project dealing with research problem identification and collaboration with local agencies, research progress summary, and future plans. The project budget and actual expenditure will be presented in a separate document.

RESEARCH PROBLEM IDENTIFICATION AND COLLABORATION WITH LOCAL AGENCIES

Bangladesh

During the past few years, IRRI, the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Water Development Board (BWDB) have conducted collaborative research in the service area of two irrigation systems -- the Ganges-Kabodak lift-cum-gravity irrigation system [total potential service area = 126,000 hectares (ha)] and the North Bangladesh deep tube well system (total no. of tube wells = 381). These systems represent two major types of irrigation technology in Bangladesh. The primary objective of the research has been to help develop feasible means of improving utilization of irrigation water and promote improved cropping practices for higher production and farmer income. While the field research activities are entirely conducted by the researchers of BRRI in collaboration with and participation of local BWDB personnel, the role of IRRI has been mostly to support planning, analyzing and reporting of the research, and in formulating strategies for their proper use by concerned institutions and personnel.

Results from this research have made some significant improvements in the management of irrigation water in the two systems as well as in the crop production practices of farmers. However, it is clear that the potential for such changes is much more than what has been internalized so far by the farmers or the irrigation managers. The IIMI-IRRI collaboration in Bangladesh is conceived to enhance the process of internalization of the available results and to generate relevant new information in support of the major objective stated above.

IIMI started its work in Bangladesh in November 1988 when an expatriate senior staff member (an agricultural economist) was stationed in the country. Before then, as stated earlier, a limited consultation was done in Dhaka by the IIMI and IRRI project coordinators with senior national staff from the BWDB, BRRI, the Bangladesh Agricultural Research Council (BARC), the Bangladesh Agricultural Development Corporation (BADC), the Bangladesh Agricultural University (BAU), the Bangladesh Institute of Development of

Science (BIDS) and the Bangladesh Rural Development Board (BRDB). The three basic hypotheses suggested earlier to guide the collaborative work between IIMI and IRRI in Bangladesh were taken up. These were: 1) that the need for rice production in Bangladesh will continue at a level sufficient to maintain the basic economic value of rice production in irrigation systems; thus, a focus on increasing the efficiency and equity of rice production is logical; 2) that the agricultural and irrigation techniques to increase rice productivity already proven to be successful can be extended more widely in the government irrigation systems, with adaptation to site-specific conditions; and 3) that organizational and institutional modifications may be needed for implementation and maintenance of revised irrigation procedures. It was recommended that the project capitalize on what the ongoing BRRI/BWDB/IRRI has done in the past, and build on the results obtained with a view to achieving more than what has been possible so far. It was made clear that IIMI's interest and emphasis on main system management would complement the on-farm mandate of IRRI. Moreover, it was also agreed to continue with the consultation needed to finalize the workplan for the Bangladesh component as soon as the IIMI senior staff member was appointed.

Indonesia

The collaborative activities started with a series of discussions at IRRI on 9-10 April 1987 among scientists and administrators from both IRRI and IIMI. Planning meetings in Indonesia, involving IRRI, IIMI, the Directorate General for Water Resources Development (DGWRD), the Agency for Agricultural Research and Development (AARD) and the University of Gadjah Mada (UGM) took place in June and October, 1987 and March 1988.

The research activities for the project were identified during the above planning meetings and in a workshop held at Cirebon, West Java on 10 June 1988. The workshop also discussed the detailed workplan for each of the collaborating institutions.

The primary objective of the project in Indonesia was to develop and test irrigation system management strategies that take into account variations in the physical environment, crop management, water availability, and farmers' decision making.

Current system management practices, largely based on the pasten system or derivatives thereof, already respond to certain aspects of demand and supply but are relatively insensitive to variations in physical conditions. Through the Irrigation Committee, seasonal cropping plans are drawn up based on previous experience but it is clear that there are significant deviations from this plan during each season. Bi-weekly estimates of planted area and average water demand are obtained and compared with estimates of water availability during the same time period. As long as supply exceeds demand, the systems operate largely on a continuous flow basis to all parts of the irrigated area, leaving farmers to make local adjustments where needed. When supplies are inadequate, rotational irrigation is implemented between tertiary blocks along a secondary and, under more severe conditions, between secondary canals.

Within this overall pattern, the role of irrigation system management is to attempt continually to match variations in demand and supply, and to do so in a relatively efficient and egalitarian manner. For this to be effective, it has to be done in two different time frames: within-season system operation and seasonal planning.

System Operation. Irrigation system management involves responses to short-term variations in actual supply and demand. Initially, research focuses on responses to existing management before moving to innovations later in the project. To maintain the focus within the context of the overall objectives of the IIMI-IRRI collaboration, the following objectives are identified:

(a) to determine optimal rotational irrigation schedules to be adopted when water supplies are inadequate to meet demand through continuous and simultaneous deliveries to all tertiary blocks. The institutional arrangements and supporting information flows required to implement alternative water delivery practices, including modifications to rotational irrigation, will be evaluated. Research will be conducted to determine current farm-level water management practices within tertiary blocks of measured land capability and to the levels of water productivity that are currently achieved by farmers, and to assess how farmers cope with variations in water supplies delivered to the tertiaries. Furthermore, research will be conducted to have a better understanding of farmers' cropping and crop choice decision in a given season, and

(b) to evaluate the relationships between irrigation system operation and groundwater fluctuations that may be detrimental or beneficial to non-rice crops and to develop methods for efficient irrigation management through the productive use of residual soil moisture and the prevention of overirrigation during periods of abundant water supply that may lead to untoward buildup of groundwater that inhibits cultivation of non-rice crops in subsequent seasons. Studies will include an evaluation of constraints that groundwater has for the adoption of non-rice crops, information on uptake of both matric and groundwater by dry season non-rice crops, how these uptakes are affected by soil management, and how they may be optimized for crop production by changes in irrigation system management. Likewise, studies will be conducted on the methods of on-farm surface drainage for improving upland crop yields in areas where excess water suppresses yields.

Annual Planning of Irrigation Schedules. The annual Crop Plan involves several components relating to the assessment of water supplies, soil and crop water demand, the allocation of cropping patterns within the system, and the development of a set of operational plans to accommodate variations in both supply and demand. In relation to this, the following objectives are addressed:

(a) to develop methods of assessing water availability better, both from rainfall and rivers throughout the year, with particular emphasis on simple methods of predicting periodicity and intensity of water deficit during the dry season;

(b) to obtain better estimations of probable cropping decisions to be made annually by farmers, which can be integrated into seasonal cropping plans; to evaluate Cropping choices by farmers, assessment of the constraints to the cropping practices, or crop establishment; to develop alternative cropping patterns that better suit variations in physical conditions;

(c) to improve procedures for dry season allocation of area to be irrigated and the crops to be grown, based on predictions of water availability at the system level and assessment of field-level demand;

(d) to develop plans for operationalizing system management from the Annual Plan to accommodate anticipated demand and probable water supplies to the system, including assessment of the capability of the system to accommodate alternative rotational irrigation practices; and

(e) to propose modification to the annual and seasonal planning process that incorporates more site-specific information and which includes feedback from performance in previous seasons.

The joint contributions from IIMI/Public Works (PU) and IRRI/AARD should lead to identification of methodologies for making system management plans more sensitive to local environmental conditions and constraints, and move away from the use of data generalized at provincial or even national levels.

The Philippines

The project component in the Philippines was discussed in consultation meetings held 15-17 October 1987 and in a workshop which followed on 27 October. These meetings and workshop identified the focus of activities for the Philippine program.

The project design emphasized an intensive participation of local institutions from the early stages of problem identification. For the Philippine component, the process started with a draft list of possible research issues prepared jointly by IRRI and IIMI researchers. The relevant national agencies that actively participated in the aforementioned workshop were the National Irrigation Administration (NIA), the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), the University of the Philippines at Los Banos (UPLB), the Central Luzon State University (CLSU), the Bureau of Soils and Water Management (BSWM), the Bureau of Agricultural Research (BAR) and the Philippine Rice Research Institute (PhilRice).

After considering a large number of research issues and problems proposed by the participants, the workshop concluded that the following be considered priority research issues to be addressed by the project:

1. Management procedures for systems with mixed cropping. There is a need to examine the current roles and decision-making procedures of both NIA and the farmer organizations. Attention should be given to the types of information utilized in decision making and the flow of information within NIA and between NIA and farmers.

2. Physical requirements to control water at various levels (main, tertiary, farms) of the irrigation systems to support mixed cropping. The implications of these requirements for design modifications should be emphasized.

3. Farmers' crop selection and management decisions in the dry season within the context of the household socio-economic situation. Factors such as water supply, profitability of various crops, availability of off-farm employment, input supply, credit availability, markets, NIA's policy concerning irrigation service fees for different crops, etc. should be evaluated.

4. Drainage options for rice and upland crops under different hydropedological, topographical, and local cropping environments. Their implications for systems design and management and the benefits and costs of investments in drainage facilities should be assessed.

5. Land conversion from puddled to non-puddled conditions and vice versa for specific soil classes in a rice-nonrice cropping sequence. Efficient techniques for this conversion should be identified and their costs and benefits assessed.

6. Use of residual soil moisture. The moisture regime in soil profiles in areas not receiving irrigation water for non-rice crops should be quantified, and techniques for exploiting them developed. Opportunities for supplemental irrigation should be examined.

7. Water resource augmentation to extend dry season service area in different types of irrigation systems. Sources of water augmentation should include shallow groundwater, ponded surface water, and intermediate storage created for this purpose.

8. Alternative allocation strategies to establish higher efficiency of water use and greater equity among farmers (rice and non-rice). Various models of rotational scheduling of water delivery should be assessed.

Within the purview of these issues, and considering the institutional background and commitments of IIMI and IRRI, it was agreed that the two institutions, either alone or together, take major responsibility for developing and facilitating research in the following areas:

1. To document and analyze the management procedures of irrigation systems with rice-based cropping. The analysis should include

assessment of factors that affect the management and decision-making process of systems managers, central office staff, and farmers as well as policy makers. The analysis should also focus on the changes that may have to be introduced in the systems designed for monocropping of rice (IIMI).

2. Assess the physical characteristics and design of the irrigation system for suitability rice-based farming system for. This will also look into the modifications that may have to be introduced in the present design to support mixed cropping (IIMI/IRRI).

3. Explore strategies and draw up recommendations for irrigation managers, farmers, and policy makers on how to manage irrigation systems for crop diversification efficiently and effectively. These include water resource augmentation to extend the dry season irrigated area in different types of systems and opportunities for alternative water allocation to establish higher efficiency of water use and greater equity among farmers (rice and non-rice). The results will help formulate policy recommendations that will support the government's effort in both maintaining self-sufficiency in rice and enhancing farmers' income from the use of ricelands through crop diversification (IIMI/IRRI).

4. Identify the physical infrastructural requirements for effective water control at the farm level to support mixed cropping after wet season rice and the methods for their optimal use (IRRI).

5. Determine and analyze the factors influencing farmers' decision making in crop selection and management during the dry season within the context of the household socio-economic situation. Factors such as water supply, soil type, farm location, profitability of various crops, availability of off-farm employment, input supply, credit availability, markets, and irrigation service fees for different crops will be investigated (IRRI).

6. Assess the status and behavior of dry season groundwater regimes in non-irrigated areas, particularly in areas adjacent to irrigated rice. The problems and opportunities that these regimes present for production of non-rice crops should be evaluated. Soil and crop management, and irrigation inputs that can maximize for non-rice crops the benefits of both matric and groundwater reserves should be identified (IRRI/IIMI).

7. Assess drainage options for rice and upland crops under different hydropedological, topographical, and local cropping environments and their implications for system design and management. Benefits and costs of investments in drainage facilities should also be addressed (IRRI/IIMI).

Four operating systems were identified as suitable sites for the project. These are the Upper Pampanga River Integrated Irrigation Systems

(UPRIIS), particularly the Upper Talavera River Irrigation System (UTRIS) in Nueva Ecija and the Laoag-Vintar River Irrigation System (LVRIS) and the Bonga River Pump Irrigation System (BPRIS) in Ilocos Norte. The criteria used in the site selection include: a) irrigation system type and size, b) presence of diversified cropping, c) current activities of IIMI and IRRI, d) presence of a variety of soil classes, e) rainfall pattern, f) existence of farmer organization, and g) location and enviorenment (whether peaceful or not). Other systems may be also be considered as necessary. For example, some studies are also conducted at the Friar Lands River Irrigation System, and Sta Cruz River Irrigation System in Laguna, and the command area of a deep-well pump (P-27) in Guimba, Nueva Ecija, and the San Fabian Irrigation System in Pangasinan.

It was unanimously agreed that the local research institutions should have a major role in the research undertakings. In pursuit of this objective, memoranda of agreement were executed with the NIA and the Department of Agriculture (DA) stipulating their roles in the project. As part of the agreement, staff from these agencies were designated to work in the project on a part-time basis. This arrangement would enable the agency to better facilitate the transfer and utilization of results of the research.

PROGRESS SUMMARY AND FUTURE PLANS

Bangladesh

A. Professional Development

A significant component of the IIMI-IRRI project in Bangladesh involves professional development activities. These activities include training of research staff, guidance of graduate students" thesis studies in relevant areas, and training of field-level staff engaged in the project. All these professional development activities will be conducted within the country; some of the training for field-level staff and farmers will be conducted in the BRRI research station. Graduate student researches will likely involve students from the Bangladesh Agricultural University (BAU), the Bangladesh University of Engineering and Technology (BUET), and possibly the Rajshani University (RU). It is anticipated that the thesis researches will focus the interest of more university faculty members in the problems of irrigation systems.

B. Collaborative Research

The collaborative research project activities in Bangladesh started in early 1988 with the appointment of a project economist and the provision of support to the on-going research under the existing BRRI-BWDB-IRRI arrangement. A selected number of specific research objectives were pursued during the year. A complete listing of on-going and planned research projects is found in Table 1. The activities and some selected research results of the two current field research sites as well as the future plans are described below.

The North Bangladesh Tube well System site has a service area with very light soil (sandy loam) and is not considered suitable for irrigated rice in the dry (Rabi) season because of the high percolation rate and consequent high water requirement. Dry season rice was found to require 6-12 times more water depending on whether the water is kept continuously saturated or continuously submerged with shallow standing water compared with the optimal water requirement for wheat. Therefore, from the time of establishment of the irrigation system the BWDB had tried to reinforce the production of wheat (and to a lesser extent, some other upland crops) in the Rabi season with the use of tube well water. This part of the country soon became a prime wheat growing area.

But since about 1986, farmers started to withdraw from growing wheat. In 1987-88, many farmers abandoned the wheat culture and switched to other non-rice crops or kept the land fallow. In the service area of the 12 selected tube wells that are under continuous monitoring for several years, the area grown to wheat declined from over 150 ha in 1985 to only 66.5 ha in the 1988 Rabi season. Many farmers switched to an early Aus (April-June) rice using tube well water that was allowed in 1988 for the first time in the system's history out of consideration for those who were determined to fallow their farms if they were not allowed to use tube well water for an early Aus rice.

A study was undertaken to determine the causes of large-scale decline in farmers' preference for wheat production in the Rabi season, and to assess economic returns from various alternative crops. The study used a sample of 120 farm plots located in the service area of 6 tube wells, each of which has an existing database covering 50 farm plots, for about five years. Preliminary analysis of the data has been completed. Although early Aus-rice was gaining more popularity, wheat was still the most dominant crop, followed by potato, in the 1988 Rabi season. About 70% of the farmers grew some wheat, mostly for domestic consumption, use of straw as fuel, and (for some) the opportunity as seed-agency's contract growers to sell wheat seeds at a high price to the agency. Those who did not grow or discontinued to grow wheat cited the following reasons: (a) low yields of popular wheat varieties: (b) need for excessive fertilizer application; (c) high cost of inputs; and (d) low market price of wheat at harvest time. A small number of farmers who had abandoned wheat cultivation are reconsidering growing the crop for reasons of having no suitable alternative crop available to them, and for domestic food and fuel demands.

A second activity initiated and supported by the IIMI-IRRI project is to computerize the database that has been created for about 500 farm plots located in the service area of the 12 selected tube wells for 5 years. Work on both these aspects is continuing under the joint supervision of BRRI's water engineers and the agricultural economist supported by the IIMI-IRRI project.

Other ongoing projects include green manuring effects on irrigated soil characteristics, optimal irrigation regimes and methods for wheat cultivation, water use efficiency comparisons between recommended quantities and farmers' water management practices, and comparative performance of selected tube wells.

In the Ganges-Kabodak Irrigation System site, research is conducted on 9 selected tertiary canal service areas -- 3 in each selected secondary canal -- representing the head, middle, and tail portions of Phase I of the system, which has a total service area of about 36,000 ha. In each tertiary area, a sample of 50 farm plots, which are well distributed over the service area is taken to establish a database for information on water use, other inputs use, cultural practices, and yields. The system functions for about 9 months (approximately from mid-February to mid-November) for two consecutive rice crops.

Research in the site that is supported by the IIMI-IRRI project includes the following topics: (a) assessment of the potential and actual productivity of different non-rice crops grown after an irrigated main rice crop using residual soil moisture (without irrigation); (b) comparative analysis of modern technology used in different parts of the system with varying water availability levels; and (c) farm-level water use efficiency and component water losses, and their impact on system-wide performance.

Results from the 1988 Rabi and the two rice (Kharif-I and Kharif-II) seasons have not yet been fully analyzed. However, partial analyses indicate that a Rabi crop using residual soil moisture only (without the benefit of irrigation water) after the harvest of Kharif-II rice is becoming a more popular practice. In the 1988 Rabi season, crops grown were "khesari", onion, gram, wheat, pea, lentil, and cowpea listed in order of popularity. Farmers use fertilizers only for wheat and onion but not for other crops. Onion is gaining rapid popularity and its average yield increased by over 30 percent relative to that of the previous year. Gram is also gaining increased popularity, but average gram yield in 1988 was about 30 percent less than that of the previous year. The yield of "khesari" grown under the recommended growing practices was about 25 percent higher than that under the average farmers' practices, but for gram and onion the two yields are about the same. This indicates the limitation of scope for improvement in productivity of these crops without access to irrigation water.

In the 1988 Kharif-I season, about 34 percent of the irrigable area received deliveries of irrigation water, of which about 95 percent of the area was under modern varieties (MV). Of the six tertiaries that were monitored for water deliveries, higher proportions of irrigable area (62-72 percent) were covered generally in the tertiaries that are located in the head-end of their respective secondary canals, but those that are under or near the tail-end of the secondaries had much less coverage (6-34 percent) of their irrigable areas. BR1 was overwhelmingly the most widely grown MV rice during the season (156 sample farmers grew this variety), producing an average yield of 3.9 t/ha. Various local rice varieties were grown by 126 sample farmers with an average yield of 1.8 t/ha. BR3 was grown by 2 farmers who achieved an average yield of 5.3 t/ha, while 8 farmers grew the IR8 variety with an average yield of 3.5 t/ha. Those growing MVs applied high amounts of nitrogen (average of 97 kg/ha for BR1), but applications in farms growing local varieties averaged only 30 kg/ha (accounting only for the 84 percent who applied nitrogen fertilizers).

Tertiary-level water use efficiency, defined as the ratio of the local water required to total water applied from irrigation source and rainfall, averaged 63 percent in the 1988 Kharif-I season and 87 percent in the following Kharif-II season. These measurements are based on four tertiary canal areas served by secondaries S4K and S9K in Kharif-I, and five tertiary areas of the secondaries in Kharif-II. The higher water use efficiency in Kharif-II is associated with much less rainfall during the season (572 mm) compared with that of the Kharif-I season (1126 mm).

Conveyance losses of water were measured at different sections of the main, secondary, and tertiary canals using the inflow-outflow method. The tertiaries of secondary canals S4K and S9K lost between 3 percent and 11 percent of water in conveyance, with an average water loss of 7 percent.

In terms of future plans, in 1989-1990, the above-described research activities in the Ganges-Kabodak and the North Bangladesh tube well irrigation systems will be continued in order to develop a wider and more complete database for an in-depth analysis of the issues and problems studied. Some significant interim conclusions and recommendations are also expected to emanate from the work. It is further recognized that some new but related studies have to be undertaken during the period in order to fill information gaps that may surface.

Consistent with IIMI's mandate and interests, a number of research problems relating to the main system level irrigation management are under active consideration for study. These problems are a logical corollary to research findings that have been generated from earlier studies at the two sites. These include the following:

i. <u>Assessing practical applicability and impact of the following irrigation policy recommendations for previous BRRI-BWDB-IRRI research</u>

a. Minimum irrigated crop acreage for tube well operation. For a variety of reasons, most of the deep tube wells in the North Bangladesh tube well system irrigate areas much smaller than their true capacity. A policy suggestion has been made that the BWDB establish a minimum acreage of promised irrigated crops for each tube well for each season, taking into account the tubewell discharge capacity before it is started for that season. In return, BWDB will increase its efforts to assure a reliable water supply to the farms. This minimum-or-nothing approach has some promise but has to be examined fully. Questions involve how the farmers are to be convinced, how well BWDB is prepared to fulfill its own commitment in the deal, the irrigation fee payment experience, farmers' organizational issues, effect on irrigated acreage over time, etc.

b. Nine-day water rotation in the Ganges-Kabodak system. The G-K irrigation system, which has a limited water supply relative to actual demand, has a policy of delivering water to a canal for a continuous period of three days out of nine in a rotational mode. It has been accepted that this policy is technically sound and if properly implemented, it will help establish higher system level efficiency and more equitable distribution of the scarce water resource. But the rotational method is not functioning properly and upstream farmers take water out of turn and often waste water.

The problems of the rotational scheme of water delivery and the feasible way of solving them deserve in-depth attention. The roles of the extension service and farmers' groups in maintaining the rotation need to be investigated.

c. Ganges-Kabodak system start-up time predictability. The system has a history of a fluctuating start-up date for the first rice season (Kharif-I), which ranges between February 1 and late March. The unpredictability discourages the farmers from making definite plans for starting seedbed and land preparation. Farmers usually wait to see water flow sustained for several days before moving to the field, which results in water wastage. The recommendation has been made that BWDB set a firm date (preferably early in February) for the start up of the system. Studies are needed to determine the practical feasibility of the recommendation from the system and maintenance point of view (the system undertakes systems maintenance activities during the time between shut-off of water deliveries at the end of Kharif-II season and start of the following year's Kharif-I season), and to assess benefits that may be accrued from adoption of this recommendation. The cost of not implementing the recommendation should also be determined. The need for a program of extension activities and information dissemination to gain the confidence of the water users over a designated period of time should be assessed if the recommendation is to be properly implemented.

2. <u>Institutional issues involving farmer organizations as well as issues associated with irrigation fee payments</u>

a. Farmer organization command areas. In both the tube well and the G-K canal system, the BWDB in its relationship with the farmers works primarily through the local village cooperatives (KSSs). The KSSs have the advantage of established village-level organizations. With regard to irrigation management, however, KSSs have certain weaknesses. First, the boundaries of a KSS are not the same as the boundaries of a tube well command area or a tertiary canal command area. A KSS has village boundaries which may include parts of more than one irrigation unit. As a result a farmer might operate in a given irrigation command area but be denied membership in the local KSS. Second, after formation, a KSS does not have to allow new members in -- even if the potential members are part of the same irrigation command area of the same village. Research is needed to determine how these weaknesses can be overcome, and how individual KSSs can be made more effective in organizing water management -- both within the command area and in terms of relating to the irrigation agency.

b. Irrigation fee payments. In both the tube well and the G-K canal system the rate of payment of irrigation service fee is very low. The situation will have to improve not only for the sake of generating more government revenues, but -- and perhaps more importantly -- for the sake of maintaining system functionality and productivity that are related to revenue generation. This is specially true in the current move toward privatization of the irrigation sector. Farmers are used to not paying an irrigation fee, partly through a long history of weak enforcement. Historical inconsistency in water services may be another reason for decision against payment. It would be useful to study the constraints to the farmers' payment of irrigation service fees, and to the collection of fees from the farmers. Issues of interest are likely to involve the role of the local KSSs, the quality of water service, incentives for prompt payment, differential for irrigation of rice vs. non-rice crops, etc.

3. System turnover. There is a move to shift tube wells from government agency control to the control of farmers or non-government groups. Such privatization plans include the BWDB's North Bangladesh tube well project. There is doubt as to whether any of these tube wells will be actually turned over within the next couple of years, but if any turnovers occur, the processes and problems should be closely examined. Issues of finance and credit and the resultant equity issues regarding the landless and near-landless may be specially pertinent. Even if BWDB does not turn over any of their tube wells within the next year or so, it may be useful to study the processes and related experience of such turnovers elsewhere in the country, such as the turnover of management responsibility of deep tube wells to the Grameen Bank.

C. Review and Planning Workshop

A review and planning workshop will be organized in Dhaka in early November 1989 to present and discuss research findings and plan future programs. This will be attended by concerned researchers and research managers from BRRI and BWDB, selected invitees from institutions such as BAU, BUET, and RU, and concerned research staff from IIMI and IRRI. The workshop will specially emphasize formulation of specific research plans for the 1989-1990 Rabi season and later periods, based on a review of the results achieved earlier.

It is planned that the project will support the participation of a few research leaders from the collaborating agencies in the concluding workshop/seminar to be held toward the end of the project period during which final research results and recommendations from each of the three participating countries (Bangladesh, Indonesia, and the Philippines) will be made.

Indonesia

A. Professional Development

Professional development for Indonesian engineers and scientists involves formal institutional courses, training visits by IRRI and IIMI specialists, and on-the-job training through collaborative research. Formal institutional courses on "Irrigation Water Management" and "Physical Aspects of Soil Management in Rice-Based Cropping Systems" were conducted at IRRI in 1987/88. The training course on Irrigation Water Management was attended by Ir. Darmadji of Directorate of Irrigation I, Jakarta, and Ir. Suliyanti of the West Java Irrigation Service, Bandung.

A course on "Physical Aspects of Soil Management in Rice-Based Cropping Systems" was attended by Mr. Iwan Juliardi (Sukamandi Research Institute for Food Crops) and Mr. Abdullah Abas (Center for Soil Research, Bogor). This course teaches the design and conduct of dry-season experiments on tillage, fertilization, irrigation, and soil-water relations of mungbean and soyabean following wetland rice.

Professional development through the University of Gadjah Mada involves research thesis support for Sukirno, Sigit Arif and Mawardi for the topics listed in Table 2.

B. Collaborative Research

Field research commenced in March 1988, concentrating on the Maneungteung Irrigation System at Cikeusik. The initial findings from these activities were presented and discussed during the workshop on 23-24 February 1989 at Cirebon. The research results presented are summarized in the succeeding sections according to the major topics being addressed and as listed in Table 2.

1. <u>Predicting Water Availability for Main System Management for Dry Season Crop Production</u>

Making plans for the operation and management of irrigation systems and their implementation require reliable and dependable information. The availability of water is the most important consideration in preparing these plans. A reliable method of predicting water availability is therefore necessary.

Reliability analysis for rainfall input to the system may be required for irrigation planning and for determining the number of rain gauges needed to provide reliable data. Using 15 years of daily rainfall data taken from 5 rainfall stations in the Maneungteung Irrigation System (MIS) showed potential to predict the receipt of 300-400 mm of cumulative rainfall and hence the beginning of the irrigation season. Using one rain gauge per tertiary block, the validity of the data is 90-95 %. The results also indicate that rainfall over the CIS is randomly distributed.

Water availability is closely related to the moisture status of the soil. The development of soil cracks may serve as an indicator of soil-moisture status in the root zone. This could help in the management of the irrigation system, especially in managing water application uniformity by using evidence of cracking as an indicator of water stress. Preliminary results showed that crack development varies from one place to another. It is related to the type of soil, the dynamics of soil-moisture content in the arable layer, the fluctuations of groundwater level, and the presence of the plants.

Soil moisture status and its distribution in the 0-30 centimeters (cm) soil layer in the tertiary block can be expressed in terms of Wetness Index (WI) and Uniformity Index (UI). It can be predicted by measuring groundwater table depth. Based on the calculated WI and UI, the supply of irrigation water in the tail area is less than in the upper area. This condition indicates that irrigation management in the Maneungteung Irrigation Area can further be improved. In the tail area, WI and UI are not uniform but wet because of drainage problems. To increase cropping intensity, drainage facilities have to be considered. The indicated soil moisture status and its distribution conformed with the observed cropping calendar and irrigation water management status in the particular area.

The successful cultivation of non-rice crops in rice-based cropping systems is highly dependent on the proper and timely delivery of irrigation water in the main canal system. Unlike rice, non-rice crops are highly sensitive to overirrigation, and there may be significant yield reductions if there is excess water: high water table conditions constrain root development. The work in the MIS in West Java showed that system-level management does not support non-rice crop production in the dry season. When river discharges are high, there is a tendency to issue more water into the system than is required. There is generally poor management response to rainfall so that total water deliveries plus rainfall greatly exceed rice and non-rice requirements, drainage flows increase, and the soil remains saturated. Even during rice harvesting, flows into the system and into most tertiary blocks are maintained, thereby preventing the soil from drying to enable easy establishment of non-rice crops. They also encourage farmers to believe that there is sufficient water for land preparation for rice in the first dry season.

In the initial stages of the first dry season, total water deliveries are above demand, again discouraging farmers from establishing non-rice crops, and forcing tail-end farmers to leave a significant proportion of their land fallow and unproductive. Gatekeepers do not concern themselves with actual demand but issue water freely, if it is available, into smaller tertiary blocks at the expense of tail-end areas that are comparatively short of water for both rice and non-rice crops.

For system level management to be more responsive to the demands of non-rice crops, it is necessary to view water deliveries within the context of both the current demand and likely demand in the next season. Although there may be no loss of production of rice due to excess water deliveries in the wet season, this overirrigation may have substantial effects on the potential for cultivation of non-rice crops due to adverse drainage and soil water conditions.

There is a responsibility of gatekeepers, particularly at the head of the system and at individual gates, to ensure that overirrigation does not occur. At the system head, flows must be reduced in times of heavy rainfall even though there may be more than sufficient water in the river. For this to happen there needs to be improved communication between the head end and tail ends of the system.

The effects of overirrigation in the transition period between the wet season and the first dry season can be attributed in large measure to the ease of management when water is relatively abundant. However, experience over several seasons indicates that it is inevitable that water will be in short supply by June or July, and that merely issuing water because it is available in April and May only postpones the problem. Farmers who are forced to grow rice due to excess water conditions are frequently the first to suffer when the river discharges drop, and the net result is loss in production and increase in tension between farmers and the Public Works.

A more integrated plan of water management for both the wet season and the following dry season should lead to higher productivity and more efficient management than is demonstrated by this evaluation of existing management practices. Other factors such as location and time related to the availability of irrigation water in the main canal have also to be considered. Data on flow characteristics in terms of velocity and discharge, and travel time under the existing physical condition of channel structures and management during the dry season, indicated that there was a significant time lag between the time of release and time of arrival at a particular site in the main canal. The availability of the irrigation water at a particular location depends on the location of the tertiary block with respect to the source along the main canal and the existing discharge. To obtain equity in water distribution, it is suggested that the travel time should be added to the time allocated for distributing water at each block in rotational water distribution.

2. Farmer-level Decision Making and Management of Dry Season Water Distribution

Accurate perceptions about farmer practices, capabilities, and forces that affect them are necessary in order to assist the government in finding the right management regimes and mixes between farmers and agencies. This is equally important for the performance criteria of both productivity and sustainability.

In the Maneungteung Irrigation System (MIS) the observed prevalence of interpersonal water distribution in the tertiary blocks generally has not meant disorder or a basic misallocation of water, despite some observed abuses and tensions. On the whole, such distributional practices are generally aimed at counteracting the effects of the physical inequalities in water needs and modes of access between irrigated parcels. Farmers distribute water through two basic modes of management: a) explicit, group-level rules and arrangements; and b) interpersonal, ad hoc adjustments. Both were present and essential in each of the systems observed, public and private, large-scale and small-scale.

The ad hoc mode does not necessarily prevail only where the Water Association (WUA) or the formal mode is weak, but its existence and scope is more fundamentally related to a need to adapt in a more micro or discerning way to a variety of factors which invariably impinge on the water needs and forms of access among farmers. It comes into play where greater flexibility and specificity is required than can be managed by the typically single-factor nature of most formal distribution rules. It may be handled by individual or interpersonal actions. To insure that such actions do not sacrifice the general welfare, they must be based on a widely recognized set of justifying criteria for augmenting the distributional rule. Where such recognitions are not generally well developed, ad hoc adjustments may need to be handled through a central mediator operating on a demand/request rule.

Both management modes at the farmer level rely on cooperativeness among the water users. Such cooperativeness may or may not be articulated through a formal WUA. Its ability to emerge and support effective and equitable water management is related to many socio-technical factors. Among the factors influencing its emergence were local social homogeneity, the need for a group effort to adapt to water scarcity or implement an agricultural production strategy (which may be either commercial or subsistence oriented), labor arrangements, and local government support.

Irrigation agencies have a limited and indirect, but nevertheless important, role to play in encouraging, or at least not discouraging farmer-level cooperativeness in water management -- inasmuch as such are within the management objectives of the main system.

3. Water-Related Constraints, Opportunities and Land Suitability and Management for Nonrice Crops Following Rice

The groundwater table in the coastal plain area of ricefields is usually shallow. It develops either from the prevention of normal movement of fresh groundwater toward the sea by the denser body of seawater or from the accumulation of percolated irrigation which is excessively applied to the entire irrigated areas, or from both sources. To a certain depth, shallow groundwater is able to supply the required soil moisture through capillary rice. Under this condition, upland crops can be grown favourably with minimum irrigation.

Irrigation management in Indonesia has not yet taken into account the potential contribution of groundwater in crop production. Its processes of development and its effect on root growth when the root zone becomes saturated have to be studied. Initial results showed the great potential contribution of groundwater to the direct supply of soil moisture for upland crops in the Maneungteung Irrigation System.

The analysis of the groundwater hydrograph, its development process, and contribution to the available moisture in the dry season in PB VII/PB VIII tertiary blocks of the Maneungteung Irrigation System, showed that recharge due to irrigation only affects fluctuation of groundwater in the area close to offtake structures and secondary canal. In the other areas, fluctuation is due more to subsurface flow. With respect to these observations, PB VII/PB VIII tertiary blocks can be divided into three areas with different characteristics: a) area with groundwater development primarily affected by irrigation, b) area with water shortage problem in dry season, and c) ill-drained area.

Three models according to the soil depth have been developed through regression analysis. Verification of the model showed that the models perform better in the lower depth.

Land productivity of the area is quite low since only the irrigation-affected area can be planted with secondary crops. To increase land productivity, water distribution in the tertiary block should be made more uniform and equal by strengthening the water user organization, and introducing a drainage system to alleviate the drainage problems.

Land suitability is an estimation of the extent to which soil can be used for the profitable production of particular crops. There are many factors which affect the growth of the crop both with regard to soil and water management and the environment. For the purpose of land suitability classification, ratings are divided according to actual conditions (without improvement) and potential (after improvement of certain limiting factors).

The soils of the Maneungteung Irrigation System are generally good for lowland rice in terms of physical and chemical characteristics, except in some parts of the middle and tail-end sections. The most suitable area for lowland rice is found in the lower areas. Major physical characteristics that may limit the intensification and expansion of secondary crops after lowland rice are a) high plasticity of the soil causing difficulty in land preparation, and b) low permeability of the soil causing poor aeration.

In the Maneungteung Irrigation System, soil-water characteristics show that the head, middle and tail-end sites have similar water holding capacities. In the first dry season, flood irrigation of adjacent fields raised water tables to within 20-40 cm of the ground surface at the head elevation, and to within 50-60 cm at the middle and tail elevations. The shallowness of the water table at the head elevations resulted in no response to tillage or irrigation. At the middle elevation, mungbean yield responded significantly to tillage: 0.73, 0.85 and 0.96 t/ha respectively, for zero tillage, seedzone hoeing, and seedzone rotovation. There was also a significant response to the total water (irrigation plus rainfall) accumulated during the period 0-45 days after sowing (vegetative period) and during 0-60 days after sowing (entire season): about 0.1 t/ha additional grain from each additional 60 mm of water.

In the second season, rainfall and flood-irrigation of neighbouring fields raised water tables to within 20-40 cm of the ground surface throughout the growing season at the tail elevation and within 40-90 cm at the head elevation (no studies were made at the middle elevation). Emergence percentage was the same (about 86%) at both head and tail elevations and for zero tillage and for hoeing/rotovation. Because of frequent rains, soil strength at both elevations and for all treatments was less than 0.07 MPa in 0-50 cm depth - too low to impede rooting, which was however constrained by the shallow groundwater regimes in the tail elevation. Plant height at maturity was correspondingly less (41 cm) at tail as compared to head (67 cm) elevation. Weeds were also more prevalent in the tail, and were higher with zero tillage than with hoeing + rotovation. Because of shallow groundwater, weeds, army worms, and rats, the yield at the tail elevation was essentially zero. The yield at the head elevation was the same without tillage (0.94 t/ha) as with tillage (0.89 t/ha); the lack of response to tillage is a consequence of the frequent rains (total 180 mm) and persistently high soil moisture. The yields at the head elevation were about 25% higher than those obtained by farmers in the neighbouring fields.

Studies on water use and yield of several vegetable crops in the Maneungteung Irrigation Area showed that the yield of onions varied from 12 -21 t/ha, using a total of 278-812 mm of water. On the other hand, the yield of string beans ranged from 1.6-8.1 t/ha, using 139-489 mm of water. The yield of onion is affected by drainage conditions and frequency of water application. The yield of string beans tends to increase at field capacity condition. The yield of chili was relatively low under excess water application.

C. Review and Planning Workshop

The workshop was attended not only by the participating collaborating agencies but also by representatives of provincial and local agricultural, irrigation, and administrative agencies.

In addition to the detailed reporting of the preliminary results from the first year of activities, the Planning and Review Workshop held on 23-24 February 1989 also addressed ways in which the individual research activities could be better coordinated, and what inputs would be required from different government agencies to better utilize the findings made so far. The workshop program and participants are given in Appendix A.

With participants largely representing the cooperating agencies, the detailed reporting of research results showed that there was considerable potential for incorporating additional information of site-specific conditions into the irrigation system management activities. This was true both for the annual planning activities as well as for within-season system operation. It proved possible to draw clear linkages from studies being undertaken by different institutions and by researchers from different disciplines.

In the second part of the workshop there was a presentation of the conclusions and recommendations on how both planning and operational activities could be improved to be more responsive to the actual cropping conditions while taking into account constraints to wider crop diversification. These constraints include farmer decisions, soil and groundwater limitations, location within the system, and information flow within the operating agencies.

Concern was expressed at the workshop that while the results of each of the research activities showed that good progress had been made, there was still room for greater coordination between the different studies. The major difficulty in this regard was the extent to which it was possible for Public Works to include more indicators of water conditions within the system at any given time, and modify existing operational conditions to accommodate the greater amount of more site-specific information being generated by the research results.

With regard to interagency coordination it was agreed that this type of collaborative research activity provided opportunities for greater coordination between line agencies within the provincial and district administration. There would be opportunities to use the data provided within the existing channels of communication such as the Irrigation Committee, and through special meetings.

The participants in the workshop also felt that although many of the results were still preliminary, some of the results were sufficiently well documented for clear conclusions to be made. To this end, a follow-up of the workshop was arranged for field-level members of the agricultural services, together with representatives of the local administration and local universities. At this follow-up workshop held on 2 March 1989 in Cirebon, a limited set of recommendations was presented for consideration for adoption in the normal activities of these staff.

The presentation was attended by 50 representatives of the Department of Agriculture, the Directorate of Agricultural Extension, the Ministry of Home Affairs, and local universities. Following presentations of the results by members of the research team from IIMI, Public Works, Sukamandi Research Institute for Food Crops, Soil Research Institute and University of Gadjah Mada, discussions were held on how field-level staff of the agricultural agencies could better utilize the information available.

D. Future Activities

After the interagency coordination meeting, the principal research staff continued with the deliberation on the future project activities and agreed to:

1. Continue the conduct of ongoing studies basically as per workplan but taking into consideration the suggested modifications raised during the workshops both in terms of research methodology and using more appropriate field research sites.

2. Support attendance to relevant training programs and conferences or research staff in the project.

3. Conduct another project review and planning workshop in October 1989 which will probably take place in the Gadjah Mada University. This would enable review of the 1989 dry season results and preparation of a plan for the rest of the project.

4. Prepare for an intercountry workshop towards the end of this project (end June 1990) to be held at IRRI to integrate the results and recommendations of the research in the three countries.

The Philippines

A. Professional Development

The project has supported national staff to attend relevant training programs and conferences or participate actively in the research (Table 3). A senior staff member from PCARRD was offered a research position with IIMI through the project to assist in the coordination of the activities in the Philippines, and at the same time conduct his own research. This secondment from PCARRD is viewed as an effort towards professional development in line with the common goals of PCARRD and IIMI to improve the capability of their scientists.

Two pre-doctoral fellowships and one pre-masteral scholarship were granted to graduate students to conduct their thesis research on problems relevant to the project. One of the Ph.D. students is also an affiliate research fellow of IRRI. A modest stipend and thesis support are provided by the project. As research fellows and scholars, they also participate in workshops that review the progress of the project.

A number of national staff also had the opportunity to attend relevant training courses through the support of the IIMI-IRRI Project.

These included courses like irrigation water management, physics and management of rice soils, and crop-weather modeling. One staff member each from the BSWM and PhilRice attended the two-month training course on "Physical Aspects of Rice Soils Management" at IRRI from February to April, 1988. They were joined by collaborators from the Indonesian component of the IRRI/IIMI Project and from other projects that have strong emphasis on soil and water management. Participants had the opportunity for regular one-to-one follow-up discussions to review the progress on the application of the training ideas and methodologies derived from the course. The course also included a two-week instruction on theoretical and practical aspects of rice production.

Two staff members from the NIA attended the 6-week training course on "Irrigation Water Management" on 29 August to 7 October 1988 at IRRI. They came from the First Allah River Irrigation System in South Cotabato and the Ilocos Norte Irrigation System in Laoag City. The training course is designed to enhance participants' concepts, understanding and knowledge of, and skill in, practices for effective and efficient management of irrigation water. The engineering, soil-plant, and socio-economic factors that individually and interactively determine water use efficiency in irrigated agriculture are emphasized. Relevant research results generated at IRRI and other institutions are utilized.

One staff member from the Department of Agriculture and one from NIA are seconded to the project on a part-time basis, providing them with on-the-job training and facilitating the transfer of research results for possible implementation by the agencies concerned.

B. Collaborative Research

Eleven research studies were presented and discussed during the review and planning workshop. Four of these were conducted under the supervision of IRRI scientists while the rest were undertaken by the IIMI fellows and scholars and other national research agencies (Table 4). Initial results of these researches are summarized in the succeeding section according to the major topics being addressed.

1. Irrigation Management Procedures for Diversified Cropping

Documenting and analyzing the management procedures followed by the irrigation agency and the information from which these procedures are based would provide benchmark data on the problems and opportunities of crop diversification in rice-based systems. This concern is being addressed in Studies 1, 5, 6, 7, 8, and 9. (See Table 4).

In the Upper Talavera River Irrigation System, in the 1988 wet season, water supplies were allocated at 2.0 liters/second per hectare (l/sec/ha) and 1.5 l/sec/ha during land preparation and crop maintenance stages, respectively. Irrigation water flowed continuously and simultaneously among laterals to serve about 3,615 hectares of rice.

Land soaking/land preparation was distributed within a period of nine weeks from the first week of July to the first week of September with the peak occurring in the third week of August.

Data for two cropping years showed that during the wet season, the whole service area is being programmed for lowland rice. Water flow is continuous in all canals unless water shortage occurs, when rotation is resorted to. The wet season delivery usually starts in June and the harvest of the wet season crop is normally from October to November. The dry season operation starts in the first week of December.

During the dry season, normally about 500 ha is programmed for irrigation to be planted to diversified crops and about the same area is programmed for planting lowland rice. In most years, the planted area is more than what is programmed in the dry season. Some unprogrammed areas are also planted because the available water during the start of the season (December) is more than enough to serve the programmed area. This causes water shortage later in the season. Instead of totally cutting off water supply to unprogrammed areas, the system resorts to rotation by section of the main canal to allow all planted areas to make use of the limited water. The usual rotation period is one week.

There are three Farmer Irrigators' Associations (FIA) in the system: the CRISTA MAKITA FIA, covering the areas grown to mixed rice and upland crops; the CATANAKA FIA, for the areas grown entirely to upland crops; and the TUSITA FIA for the areas grown entirely to rice. The extent of their involvement or participation in system management activities as well as the communication patterns varies greatly. For example, the CRISTA MAKITA FIA is now under contract with NIA for irrigation service fee collection and joint management activities while the TUSITA FIA is inactive. The CATANAKA FIA is under contract with NIA only for joint management activities.

In all three FIAs, formal farmer irrigators' groups (FIG) or informal groups exist at the farm ditch level. The FIG leaders serve as links for information among the individual farmer members, FIA officers and NIA field personnel. The informal groups consist of members who generally discuss and bring their problems directly to the ditchtenders or watermasters. Among the three FIAs, only the CRISTA MAKITA FIA was found to follow a more organized communication pattern from the individual farmer to the NIA field personnel. In the CATANAKA FIA, communication flow was disrupted between the FIG and individual farmers while in the TUSITA FIA, there was communication disruption between the FIA and FIG, and between the FIG and individual farmers. In both of these FIAs, individual farmer problems were brought directly to the ditchtender or watermaster of NIA.

In the San Fabian River Irrigation System for wetland rice, water allocation for land preparation and crop maintenance were based on 2.4 l/sec/ha and 1.7 l/sec/ha, respectively. In most of the weeks, irrigation supplies for about 4,000 farmers were made reliable by uniformly distributed rainfall. When the system water supplies fell short of water demand for rice, irrigation personnel rotated water delivery by division, almost by laterals.

For the dry season cropping, diversifying farmers started preparing dried and previously puddled ricefields with soils of an average bulk density of 1.46 grams/cubic centimeter (g/cc). To improve tillage, weed control, and soil properties, farmers alternately dried and wet the ricefields. After the wet season rice had been harvested, the fields were allowed to dry. About 98 mm of irrigation was then applied to ease up the first plowing. Soil clods were allowed to dry to an average of 7.2% moisture content, after which 260 mm of water was applied again. The second plowing started as soon as gravitational water had drained. The fields were then harrowed and pits made for transplanting tobacco. Immediately after transplanting tobacco, eggplant, tomato or seeding cotton, the fields were flooded with 103 mm of water. Diversifying farmers used about 461 mm of water from first plowing until transplanting or seeding crops.

In the Laoag - Vintar River Irrigation System, the irrigation plan for the crop year 1988-89 was discussed in a joint NIA-IA two-day review and planning workshop on 10-11 May 1988. It was planned to stagger the start of water delivery from the upstream to downstream. The total area programmed for the wet season was 2,341 ha, 36 ha less than the total service area. The area not programmed for irrigation was in Division 1 (10 ha) and Division 2 (26 ha).

The area programmed for the 1988-89 dry season cropping was 1,613 ha: 976 ha and 637 ha for rice and other crops, respectively. This is 68% of the total service area. The area programmed for rice is concentrated on the upstream and midstream portions of the system (Laterals A to G and upstream of Lateral F) while that for non-rice crops is in the downstream portion.

Total irrigated area for the 1988 wet season were about 2,251 ha, 96% of the programmed area. Most of the areas that were not irrigated were those washed out along the Vintar River while those in Division 3 were located at the tail-end of Lateral H. The unserviced areas in Division 3 and other parts of the system were not planted as scheduled. Instead the farmer-tillers chose to let their farms remain idle for the season so they could plant non-rice crops early in the dry season.

Irrigation water was observed to be continuously flowing in the main canal and all the laterals. The rotational method of water distribution was observed during low flows at the tail section in Laterals F, F1, and H and the end of the main canal. The schedule that was followed was the one taken up during the pre-operation meeting between the NIA and FIA. The rotation was implemented by district.

2. Physical Control Requirement for Crop Diversification

The changes and modifications that may have to be introduced to accommodate the requirements of upland crops in rice-based systems are addressed in Studies 1, 5, and 8 (Table 4).

In the UTRIS, the average service area of each turnout (outlet) is 54 ha for those sites grown to mixed rice and upland crops, and 49 ha for those grown entirely to upland crops. During the 1988 dry season, 72% of mixed crop area was planted (24% to rice and 48% to upland crops, mostly onion) while only 52% of the latter area was actually planted. On the other hand, the average service area of a turnout planted entirely to rice is only 13 ha, of which 4% was planted during the 1988 dry season. The greater hectarage that is planted in the mixed rice-upland cropped areas could be attributed to the relatively higher amounts of irrigation water diverted to these sites because of their more advantageous location within the top one-third section of the main canal.

The layout and intensity of farm-level facilities (e.g., water control, and main and supplementary farm ditches) in the different turnout areas vary depending on their location. For example, in the site that is grown entirely to upland crops, the average farm ditch density is 154 m/ha during the dry season but about 50% of these farm ditches are either erased or unused during wet season rice cultivation. Because of inadequate irrigation water delivered into this site during the latter part of the dry season, farmers installed shallow well pumps. There were 11 such pumps found in the area. Where appropriate, extra and ungated turnouts were also used to facilitate the diversion of irrigation water from the supply canal (lateral or main canal). In contrast, in the area belonging to the top one-third section of the main canal (mixed crop area), only a small increase (4-18%) of farm ditch density from the wet season density of 104-108 m/ha, was established during the 1988 dry season.

All onion farmers, regardless of location, constructed internal, multipurpose farm ditches along the perimeter of each plot to facilitate irrigation and drainage and to intercept seepage water from adjacent plots or farm ditches. About 10-15% of the farm land is utilized for the construction of these multipurpose ditches during the dry season. But in the wet season, these are erased and the area released is grown to rice. The average rice field size is about 1000 square meters, which is divided into two or three smaller plots to facilitate water control for dry season onion crops.

Within each turnout area, farmers practice rotational allocation and distribution of water. Water is applied by basin flooding (flushing), wetting each plot from the top to the bottom end, and draining the excess water immediately to avoid waterlogging.

A regression model relating the plot area to water application rates, duration of irrigation, interval of irrigation, and farm management practices (mulched and unmulched) was developed. Using this model, it was estimated that the area which can be irrigated each day by a turnout discharge of 130 l/sec for 10 hours per day is about 5.2 ha for mulched and 4.6 ha for unmulched onion. Therefore, for the usual schedule of a 3-day rotational water delivery, the total area within a turnout that can be grown to irrigated onion with mulching is about 15.5 ha.

Irrigation water used for dry season rice averaged 1,310 mm, of which about 430 mm was used for land preparation and the remaining 880 mm for crop growth. In contrast, onion crop water requirement was about 435 mm for mulched and 940 mm for unmulched plots. The frequency of irrigation was less for mulched onion (3-5 times) compared with unmulched onion (8-10) times) or rice (10-15 times). Unmulched onion farms were given the first irrigation 8-14 days after transplanting, whereas mulched onion received the first irrigation only 21-48 days after transplanting.

Results indicate that the basic farm-level facilities required for rice irrigation are useful for upland crop irrigation in the dry season, and some additional water control facilities that are needed for the upland crops can be suitably and adequately handled by the farmers.

3. Farmers'Decision-Making Processes Related to Crop Diversification

In crop diversification, the farmers' decision as to what crops they will grow, the planting calendar to follow, and other activities are affected by many factors. These include availability of water and socio-economic factors that have to be analyzed to have a better understanding of how diversification may progress in the future. Study 4 (Table 4) looks at the irrigation-related constraints to dry season crop choices at the farm level and how farmers respond to these constraints.

In irrigated lowlands, when returns from non-rice crop production in the dry season are higher than the returns from rice production, the demand for, and the price of, land with fewer constraints to diversified cropping in the dry season are higher. In the UTRIS, the major upland crop grown in the dry season is onion. The returns to dry season onion production were higher than the returns to rice production and one observed a movement in land demand away from lateral A (heavy clay soil) to the other parts of the system with lighter soils. Land values in Lateral A which were once the highest in the entire system are now lower than those for comparable lands in Lateral B.

Relative to rice, onion production requires a larger financial outlay for inputs, a greater input of labor and supervision time on the part of the farmer, and a larger effort made to diffuse the impact of price risks. The credit constraint to onion production has been alleviated by arrangements with onion traders who provide credit for the purchase of all the required inputs in exchange for a commitment from the farmers that they (traders) have the exclusive right to purchase all output at the market price at harvest time.

Supervision time rather than the higher labor requirements are the dominant labor constraint to onion production. This is so because of the highly inelastic nature of management labor in the farm household while hired labor supply, being augmented by seasonal migrants, tends to be relatively more elastic.

Farmers in the low sections of the irrigation system and those further away from the irrigation canals have to be more efficient in their water use. Water supply is not reliable for these farmers and even if they do get the water, the quantity is only a fraction of that available to the more favorably located farmers. They use supplementary irrigation from shallow well pumps. In terms of payment of irrigation fees, however, the farmers near the irrigation canals are the ones most delinquent.

Improving water use efficiency would require both system-level and farm-level adjustments. At the system level this would imply changes in water scheduling and allocation rules to reflect the evolution from rice monocropping to diversified agriculture. Irrigation fees have to be revised to account for difference in water use rather than a flat fee for any non-zero water user.

Individual farmers will be interested in joining irrigators' associations only if the benefits they get from membership exceed the costs they have to bear. The benefits of belonging to an irrigators' association are high when collective action is needed and when it is feasible. Collective action is needed a) to ensure adequate water supply, b) to regulate timing of water supply, and c) to prevent excess water into the non-rice crops.

4. Drainage Requirements for Crop Diversification

Upland crops require less water than rice, and aeration is necessary for them to grow. In irrigated lowland rice areas, drainage is as important as irrigation. This is addressed in Studies 4, 10, and 11 (Table 4). The study in Guimba, Nueva Ecija looks at the drainage options for upland crops in heavy clays (57%) and in high water table areas. Design methods of on-farm surface water control systems using available information on upland crop drainage requirements and engineering principles are developed and evaluated. Also being evaluated are alternative options and farm-level strategies and techniques to optimize the use of water resources for maximum crop production in irrigated rice systems.

In the UTRIS and SFRIS, areas with potential drainage problems are identified and monitored. Water conditions and drainage rates in the field after irrigation or rain are observed. This is particularly important in planning for planting the upland crop after lowland rice. The hydropedological properties of the soils are also being evaluated.

5. Land Conversion for Crop Diversification

The difference in the environmental requirements of lowland rice and upland crops necessitates a study on the conversion of a submerged and puddled soil condition to an aerated, well-drained soil for upland crops and vice versa. Studies 2 and 10 (Table 4) address this concern.

At UTRIS, the experiment aims to determine the effects of, and interactions among, tillage, mulching, and irrigation on the growth and yield of mungbean following rice. The tillage/seeding methods were: tillage followed by planting of mungbean; the farmer's method of plowing the field followed by broadcasting the seeds, and then harrowing with conventional plowing and harrowing followed by row planting; and finally, deep strip tillage followed by conventional tillage, with row planting of mungbean. These were combined factorially with treatments without and with rice-straw mulch at the rate of 1.6 tons/ha. Furthermore, these were factorially combined without and with irrigation of 80 mm at 38 days after sowing.

The results showed that the average yield response to deep or conventional tillage was an increase of 40%. For non-mulched plots, deep tilled treatments gave a 20% decrease in yield. Emergence and plant height increased by 9%, and yield by 26% in mulched plots. In response to irrigation, plant height increased by 20%, and yield by 21%. Mulching plus irrigation increased yield by 49%. The constraints that caused the low yields were poor emergence because of high seedzone strength, low soil fertility and heat stress.

The hydrological characterization of the area will provide additional information to identify the most appropriate management practices to seasonally convert ricelands to diversified crop areas. It will characterize in greater detail the soil factors that may have contributed to or constrained crop diversification.

6. Water Resource Augmentation

Studies 2, 10, and 11 (Table 4) address the issue of water resource augmentation. If the relatively inadequate water supply in the dry season could be alleviated, the cultivated area could be extended by tapping other sources of water and planting non-rice crops.

At UTRIS, observation pipes have been installed to monitor the groundwater levels. Observations showed that geographically within the system, the shallow water table early in the dry season was found near the main canal and near the deep wells at the peak of the dry season. It was also observed that 14% of the sites had potentially exploitable water that persisted for 20-77 days, and a further 22% had water for between 1 and 20 days which could possibly be managed for the benefit of dry season non-rice crops.

The above observations will be complemented by documenting the augmentation practices employed by the farmers to come up with improved schemes for diversified cropping. This will be done in three selected areas in the system, i.e., areas where non-rice crops are planted alongside rice and water supply is not a serious problem, areas where only non-rice crops are planted and irrigation water supply is limited, and non-rice areas where irrigation water supply is expected to be completely cut off.

C. Review and Planning Workshop

With the purpose of assessing the progress of the collaborative project, identifying the constraints, if any, in its implementation and their possible solutions, and planning for future activities, a review and planning workshop was held at IRRI on 20 December 1988. The workshop program and participants are listed in Appendix B.

In addition to the progress highlights on the manpower development and research activities of the project presented in the preceding sections, the workshop provided a venue for sharing what everybody is doing and how one's project could relate to the others. Important discussions were held concerning the establishment of procedures for sharing of data and for increased coordination and complementation. Sharing of data was emphasized with the end in view of avoiding duplication and for reinforcing the data/information that are already being collected.

Recommendations made by the participants for better coordination and complementation include the conduct of regular meetings of the different researchers involved, and providing copies of reports to relevant agencies. The workshop further recommended to hold another coordination meeting after the present dry season cropping. This meeting which is now scheduled for 24 August 1989 at the NIA building envisions greater participation of the people in the field, especially those from the NIA and the DA.

The group also agreed on a timetable for preparing a consolidated report to the Rockefeller Foundation. This included a format to be followed by researchers in preparing individual progress reports, and a list of research issues which would show the interrelationships of the various studies.

D. Future Activities

After reviewing the progress of the project, the workshop recommended the following:

1. Continue the implementation of the ongoing studies as per their individual workplan with due consideration for the comments and suggestions raised during the workshop.

2. Consider other research proposals submitted for funding support by project. These could be through contract research with national institutions or through thesis research of fellows and scholars.

The evaluation and approval should consider the time frame of the project.

3. Continue the conduct of coordination meetings among all researchers involved in the project.

4. Conduct another project review and planning workshop in August 1989 after the 1988-89 dry season cropping. This should draw greater participation from the BSWM and NIA field staff.

5. Support attendance in relevant non-degree training programs, workshops and conferences, of staff involved in the project. This would not be limited to the regular training courses offered by IRRI or other institutions.

6. Conduct an intercountry workshop towards the end of the project to integrate the results and recommendations of the researches in the three participating countries (Bangladesh, Indonesia and the Philippines).

Table 1. On-going and Planned Research under the IIMI-IRRI Collaborative Project in Bangladesh.

Research title	Researchers/ Agency	Objectives	Study sites	Duration
1. Study on the irrigation effectiveness and water use efficiency in the BWDB Irrigation Projects	M.A. Ghani M.A. Sattar M.A. Rashid M.A.Kashem Khan M.Nazrul Islam M. Golam Mowla M.N. Hassan M.K. Mondal M. Nurul Islam H.R. Molla S.I. Bhuiyan BRRI/IRRI	To find out the level of water utilization in the selected irrigation projects To develop methodology for increasing irrigation efficiency of the systems	G-K and NBTP	Dec. 1981 to June 1990
2. Identification of priority areas for irrigation during *AUS* season and means to improve land producti-vity and stable income in the non-priority areas.	M.A. Ghani M. Nazrul Islam M.Jahirul Islam M.A. Sattar M.A. Rashid M.Nazrul Islam M. Golam Mowla M.T. Islam M.K. Mondal S.I. Bhuiyan BRRI/IRRI	To improve allocation and distribution of irrigation water during dry season To improve land productivity and farmers income through diversified cropping	G-K	Jan. 1983 to June 1990
3. Identification of factors influencing farmer's cropping plan in NBI project	M.A. Ghani M.Nazrul Islam L.R. Bhuiyan M.A. Rashid M.G. Uddin M.M. Hassan S.I. Bhuiyan D.E. Parker L.R. Khan BRRI/BWDB IRRI/IIMI	To find socio-economic reasons influencing farmers crop choice	NBTP	Jan. 1988 to June 1990

4.	Study effect of green manuring on the irrigated soil properties	M.J. Islam L.R. Bhuiyan M.A. Rashid M.M. Hassan M.N. Islam G.Mowla M.T. Islam M.K. Mondal M.A. Sattar M.A. Kashem Khan M.H.R. Molla M.N.I. Miah M.A. Ghani S.I. Bhuiyan BRRI/IRRI	To analyse the impact of green manuring on soil physical and chemical properties To assess the effect of given manuring on the crop productivity	G-K and MBTP	Jan.1988 to June 1990
5.	Study on the possible recycling of drainage water	M.A. Ghani M.Nazrul Islam M.M. Ali M.K. Mondal S.I. Bhuiyan BRRI/BWDB/IRRI	To determine possible use of drainage water for increasing service area of the system To explore the possibilities of of using drainage water for irrigating non-rice crops	G-K	June 1988 to June 1990
6.	Survey and evaluation of the farmers' existing cropping patterns in relation to irrigation facilities at different selected sites	M.A. Ghani Nazrul Islam L.R. Bhuiyan M.Jahirul Islam M.A. Sattar M.A. Rashid M.A.Kashem Khan M.Nazrul Islam M. Golam Mowla M.N.I. Miah M.M. Hassan M.K. Mondal M.Nurul Islam M.R. Molla S.I. Bhuiyan BRRI/BWDB/IRRI	Monitoring the changes of farmer's existing cropping patterns Assessment of the productivity and management of farmers' existing cropping patterns at the selected sites	G-K and MBTP	Dec. 1989 to June 1990
7.	Testing of some selected cropping patterns on farmers' field at selected tertiary and tube well area in relation to irrigation facilities	M.A. Ghani L.R. Bhuiyan M.A. Sattar M.A. Rashid M.A.Kashem Khan M. Nazrul Islam M. Golam Mowla M.N.I.Miah M.M. Hassan M.K. Mondal M.Nurul Islam	To identify the most productive and profitable cropping pattern for the test sites	G-K and MBTP	Dec. 1989 to June 1990

	M.R. Molla S.I. Bhuiyan BRRI/IRRI			
8. Comparative study on the performance of BWDB and BADC deep-wells & private shallow tube wells	M.A. Ghani M.Nazrul Islam M.K. Mondal M.A. Rashid M.M. Hassan S.I. Bhuiyan D.E. Parker L.R. Khan BRRI/IRRI/IIMI	To assess benefit cost ratio of the tube wells. To determine the service area and water distribution parameters of the tube wells	NBTP Bogra Rajshani	Jan. 1989 to June 1990
9. Benefit-cost analysis of G-K and NBT projects	M.A. Ghani M.Nazrul Islam M.M. Hassan M.T. Islam M.K. Mondal M.A. Rashid M. Nazrul Islam M. Golam Mowla S.I. Bhuiyan D.E. Parker L.R. Khan BRRI/IRRI/IIMI	To determine actual irrigation cost and consequent benefits	G-K and NBTP	Jan. 1989 to June 1990
10. Study on the economic trade-off between wheat and rice in dry season	M.A. Ghani M.Nazrul Islam L.R. Bhuiyan M.A. Rashid M.M. Hassan M.N.I. Miah S.I. Bhuiyan D.E. Parker L.R. Khan BRRI/IRRI/IIMI	To analyse benefit and cost of wheat and rice irrigation and its impact on the project performance and farmers income	NBTP	Jan. 1989 to June 1990
11. Minimum irrigated crop acreage for tube well operation	L.R. Khan D. Parker M.A. Ghani IIMI/BRRI/BWDB	To monitor and assess the implementation of a minimum acreage rule in a BWDB tube well project.	NBTP	June 1989 to June 1990
12. Nine-day water rotation operation assessment	L.R. Khan D. Parker M.A. Ghani IIMI/BRRI/BWDB	To monitor and assess an experiment with the enforcement of a nine-day rotation on one secondary of a major lift canal system	G-K	June 1989 to June 1990

13. Start-up time options in a major lift canal system	L.R. Khan D. Parker M.A. Ghani IIMI/BRRI/BWDB	To analyze the options and constraints associated with setting and maintaining a fixed and predictable start-up time in the time in the Ganges-Kobadak canal scheme	G-K	June 1989 to March 1990
14. Farmer organizations in command areas	L.R. Khan D. Parker M.A. Ghani IIMI/BRRI/BWDB	To evaluate the role of farmer organizations in irrigation in both an agency-operated tube well system and in a major canal system	NBTP and G-K	June 1989 to June 1990
15. System turnover	L.R. Khan D. Parker M.A. Ghani IIMI/BWDB	To examine the preconditions for tube well privatization. To assess both the possible constraints as well as the potential for tube well turnover.	NBTP	June 1989 to June 1990
16. Irrigation service fee payments	L.R. Khan D. Parker M.A. Ghani IIMI/BRRI/BWDB	To examine both the irrigation agency and farmer constraints to the collection of irrigation service fees	NBTB and G-K	June 1989 to June 1990

G-K : Ganges-Kobadak Irrigation Project, Kushtia
NBTP = North Bangladesh Tube well Project, Thakurgaon

Note: For projects 11 to 16 the complete list of researchers are not yet available. Some projects may involve additional researchers from BRRI as well as staff from BWDB --- in addition to researchers provided by IIMI.

Table 2. On-going researches under the IIMI-IRRI Collaborative Project in Indonesia.

Research title	Researchers/ Agency	Objectives	Study sites	Duration
1. Reliability analysis of extrapolated rainfall data over rice-based cropping system	R. Hadiano GMU	To determine the reliability of predicted rainfall data which have been obtained from any rainfall records	MIS, West Java	October 1988 to April 1989
2. Development of seasonal operational plans based on annual cropping plans	M.E. Busro PU	To translate decisions made at the section level into system specific operational plans	MIS, West Java	February 1988 to June 1989
3. Soil moisture status and soil cracking in tertiary block of irrigated area	Sukirno A. Rozaq GMU	To develop a method for representing the distribution of soil moisture status over a tertiary block based on surface groundwater data	MIS, West Java	February 1988 to March 1990
		To represent the distribution of available soil moisture in tertiary block for a particular crop (especially for palawija)		
		To obtain data concerning the development of soil cracks in the irrigated area of of ricefield		
		To explore the relation between cracking performance and its soil moisture status in the arable layer and the depth of groundwater table		
4. Dynamics and potential contribution of surface groundwater to the supply of soil moisture for nonrice crops	Suprodjo S.S. Arif GMU	To develop a simple method for estimating the potential contribution of surface groundwater in an irrigated area	MIS, West Java	May 1988 to December 1989
		To assess the dynamics of perched or surface groundwater in irrigated area		
5. Transit time of irrigation water along the main canal in a rotational system	M. Mawardi GMU	To analyze the influence of location and time factors on availability of irrigation water in main canal system	MIS, West Java	February 1988 to April 1990

6. Interrelationships between main system management and palawija crop production in the dry season	D.H. Murray-Rust D.J. Vermillion M.E. Busro IIMI	To evaluate main system management activities in the Maneungteung Irrigation System (MIS) in West Java with particular emphasis on water delivery conditions in the transitional period between the wet season and the start of the first dry season To determine the extent to which main system water deliveries are sensitive to the changing pattern of water demand as rice is harvested and farmers are faced with a decision as to whether to cultivate rice or nonrice crops in the first dry season	MIS, West Java	February 1988 to December 1989
7. Farm-level management of dry season water distribution in the MIS	D.L. Vermillion IIMI	To identify how farmers actually distribute water in the sample public and private systems To identify causes and consequences of of farmer management practices To suggest what factors seem to enhance farmer cooperativeness in water management	MIS, West Java	March 1988 to December 1989
8. Survey of water-related and socio-economic constraints and opportunities and farmers' decision-making for nonrice crops following irrigated rice	S.I.Bhuiyan A.M.Fagi I.Syamsiah IRRI/SURIF	To understand current farmer cropping decision choices. To determine farmer awareness on yield potentials and limitations for different cropping patterns	MIS, West Java	March 1988 to March 1990
9. Farm level productivity of water	S.I.Bhuiyan A.M.Fagi I.Syamsiah IRRI/SURIF	To determine the productivity of water use under current management conditions To develop alternative ways of utilizing water under different cropping conditions	MIS, West Java	March 1988 to March 1990

10.Soil physical constraints and opportunities and management for irrigated nonrice field crops following rice in sugar/rice/nonrice cropping systems	T.Woodhead Suwardi Abas IRRI/SRI	To evaluate effect of rice cultivation on soil physical properties To determine factors that reduce yield potential for various non-rice crops following rice To determine alternative irrigation and tillage practices that minimize negative impacts of rice production on subsequent non-rice crops	MIS, West Java	March 1988 to March 1990
11.Soil suitability for different cropping patterns	Suwardi Abas SRI	To evaluate soil suitability and support different non-rice cropping patterns in the dry season	MIS, West Java	March 1988 to December 1988

MIS - Maneungteung Irrigation System at Cikeusik, Cileding, West Java

Table 3. Professional development activities of the project - Philippine Component.

	Recipient/Agency	Nature of award
1.	Amado R. Maglinao/PCARRD	Fellowship to conduct a postdoctoral research as a seconded staff from PCARRD.
2.	Tolentino B. Moya/IIMI-IRRI	Research fellowship to complete a Ph.D. degree at Cornell University (may, 1988 to April, 1990). Also an affiliate IRRI fellow.
3.	Rodolfo A. Natividad/MMSU	Research fellowship to complete a Ph.D. degree at the Central Luzon State University (CLSU) (May, 1988 to April,1989)
4.	Herminigildo Gutierrez/USM	Research scholarship to complete the Master in Management degree at the Asian Institute of Management (AIM) (September 1988 to March 1989)
5.	Isagani Urizza/BSWM	Attendance to the two-month Training Course on the Physical Aspects of Rice Soil Management at IRRI (February to April 1988)
6.	B. Tadeo/PhilRice	Attendance to the two-month Training Course on the Physical Aspects of Rice Soil Management at IRRI (February to April 1988)
7.	Alfredo Lorenzo/NIA	Attendance to the 6-week Training Course on irrigation Water Management at IRRI (August to October, 1988)
8.	Julio Antenor/NIA	Attendance to the 6-week Training Course on Irrigation Water Management at IRRI (August to October 1988).
9.	Amado R. Maglinao/PCARRD	Attendance to the Organizational and Planning Workshop for a Research Network on Irrigation Management for Diversified Cropping in Rice-Based Systems at the AIT Center, Bangkok, Thailand on 30 November to 3 December 1988

10.	Andrew D.Valdevilla/IIMI	Attendance to the Training Seminar on Agrometeorology (Crop-Weather Modeling) at NAPHIRE, Munoz. Nueva Ecija on 14-24 November, 1988.
11.	Maximo Quiming/NIA	On-the-job training in conducting research on crop diversification in rice-based systems.
12.	Jose Torres/DA	On-the-job training in conducting research on crop diversification in rice-based systems.

Table 4. On-going researches under the IIMI-IRRI Collaborative Project in the Philippines.

Research title	Researchers/ Agency	Objectives	Study sites	Duration
1. Farm level water control and management practices for rice and non-rice crop sequence	D.F. Tabbal G.S. Bumanlag M.K. Mondal S.I. Bhuiyan IRRI	To analyze the physical and management requirements to control water at the tertiary and farm levels of irrigation systems in support for mixed cropping To evaluate the implications of these requirements for possible design and management modifications	UTRIS, Nueva Ecija	December 1987 to October 1990
2. Tillage and shallow groundwater studies for legumes following irrigated rice in previously puddled soil	M.E. Tenedora T.R. Savares T. Woodhead B. Tadeo I. Urriza R.C. Undan IRRI/BSWM/ PhilRice/CLSU	To measure and interpret the effects of tillage, irrigation, and other soil physical properties and their interactions on the growth and yield of legumes following rice in previously puddled soil To determine at what depth, for how long and for which area in the system do resources of shallow groundwater persist within depths accessible to the roots of dry season non-rice crops	UTRIS, Nueva Ecija FLRIS SCRIS IRRI Farm	December 1987 to April 1989
3. Drainage options for crop diversification in ricelands	G.J. Moridis R. Cabangon IRRI	To develop and evaluate design methods of on-farm surface water control (combination of drainage and irrigation) systems using available information on upland crop drainage requirements and engineering principles To evaluate alternative options and develop farm-level strategies and techniques to a) avert or minimize to economically acceptable levels excess water damage to upland crops, and b) optimize the usage of water resources for maximum crop production in irrigated rice systems	P-27 irrigation (deep-well fed) system, Bantug, Guimba, Nueva Ecija	October 1988 to December 1990
4. The micro-economics of crop diverisification in a diversion irrigation	P. Pingali P. Masicat P. Moya A. Papag IRRI	To understand the irrigation related constraints to dry season crop choices at the farm level To examine how farmers have responded to these constraints	UTRIS, Nueva Ecija	December 1987 to June 1990

		To identify changes in water allocation and timing rules made at the system level in response to farmer requests for change To explore possible solutions to the inherent common property problems in order to increase water use efficiency at the farm level		
5. System management study at the Upper Talavera River Irrigation System (UTRIS)	D. Cablayan A. Francisco A. Valera IIMI	To document the existing management procedures used by NIA in managing the system to irrigate both rice and non-rice during the dry season To develop and test irrigation management procedures which will improve the performance of the system in terms of preventing moisture stress in the programmed area and increased area irrigated in the dry season	UTRIS, Nueva Ecija	January 1987 to June 1990
6. Irrigation management for dry season production of corn in rice-based farming systems	A.R. Maglinao A.D. Valdeavilla IIMI/PCARRD	To evaluate and verify corn production technologies in irrigated areas with emphasis on water management in rice-based farming system To evaluate the economic returns and farmers' acceptance of dry season corn production in irrigated areas To assess the implication(s) of the change in the production system on irrigation systems management To recommend guidelines and procedures for irrigation management for dry season production of corn	UTRIS, Nueva Ecija	June 1988 to June 1990
7. Management and operation of an irrigation system for mixed cropping	R.A. Natividad MMSU/IIMI	To document and examine the irrigation planning procedures and scheme of implementation To analyze the decision-making procedures of both the NIA management and the farmers To assess the performance of the system in terms of water use efficiency and water distribution equity	LVRIS, Ilocos Norte	May 1988 to April 1989

		To develop and recommend operational procedures to increase water use efficiency and water distribution equity among farmers for mixed crop irrigation		
8. Cropping system flexibilities and the rice-specific irrigation systems	T.B. Moya IIMI/IRRI	To identify agronomic, technical, economic and social determinants of irrigated diversified cropping system To appraise structural and operational capabilities of rice-specific irrigation systems for accommodating non-rice cropping systems To determine hardware and software requirements, particularly hardware-software interactions, of innovating cropping systems flexibilities into rice-specific irrigation systems To outline guidelines for designing new rice irrigation systems or rehabilitating old rice-based irrigation systems with cropping system flexibilities	UTRIS, Nueva Ecija SFRIS, Pangasinan	June 1988 to May 1990
9. A corporate strategy for the Upper Pampanga River Integrated Irrigation Systems (UPRIIS)	H. Gutierrez USM/IIMI	To describe the socio-economic, political, technological and physical environment under which UPRIIS operates To obtain pertinent information on the actual management, organization and operation of UPRIIS To set up targets, performance standards, incentive systems and evaluation and monitoring procedures to achieve these targets	UPRIIS, Nueva Ecija	September 1988 to March 1989
10. Agrohydrological characterization of soils in rice-based irrigation systems	V.V. Babiera BSWM/IIMI	To assess and evaluate the agro-hydrological properties of soils in rice-based irrigation systems To determine the hydrological critical limits of rice soils for effective irrigation management technologies and/or dryland cropping	UTRIS, Nueva Ecija SFRIS, Pangasinan	December 1988 to November 1989

		To evaluate the viability for crop diversification of physiograpahic units grown to irrigated rice To develop strategies and draw up recommendations on the basis of the data generated		
11. Water augmentation and drainage studies in crop-diversified areas served by irrigation systems	R.C. Undan J.L. Tabago O.F. Ringor CLSU/IIMI	To document the nature and extent of water shortage and the augmentation practices employed by farmers with limited irrigation water supply To obtain information that will help irrigation systems management in formulating decisions and policies related to farmers practicing water augmentation To identify alternative water augmentation schemes for improving the productivity of rice-based and crop-diversified areas in irrigation systems with problems in water supply To document the nature and extent of drainage problems in rice-based crop-diversified areas associated with practices in the system and on the farm level To determine the effectiveness of measures applied by farmers in alleviating drainage problems in diversified cropping To determine specific drainage research priorities and concerns in irrigation systems where farmers are practicing crop diversification	UTRIS, Nueva Ecija SFRIS, Pangasinan	January 1989 to June 1990

UPRIS - Upper Pampanga River Integrated Irrigation System
UTRIS - Upper Talavera River Irrigation System
LVRIS - Laoag - Vintar River Irrigation System
FLRIS - Friar Lands Irrigation System
SCRIS - Santa Cruz River Irrigation System
SFRIS - San Fabian River Irrigation System
P-27IS - Deep Well Pump Irrigation System

Appendix A

IIMI-IRRI COLLABORATIVE PROJECT ON IRRIGATION MANAGEMENT FOR RICE-BASED FARMING SYSTEMS

REVIEW AND PLANNING WORKSHOP
INDONESIAN COMPONENT

Thursday 23 February, 1989

Cirebon Plaza, Cirebon, West Java, Indonesia

PROGRAM

A.M.

Introduction to the Workshop:	Winarno Tjiptorahardjo
Workshop Objectives:	Hammond Murray-Rust
Review of Project Background:	Senen M. Miranda
Moderator:	Busro M.E.

Reporting of Research Results:

Session I: Research of (a) Gadja Mada University

Dynamics and potential contributions of surface groundwater to the supply of soil moisture for non-rice crops	Sigit Arif
Transit time of irrigation water along the main canal in a rotational system	M. Mawardi
Soil moisture status and soil cracking in tertiary block of irrigated area	Sukirno
Reliability analysis of extrapolated rainfall data over rice-based cropping system	R. Hadiano
Summary of GMU presentation:	Suprodjo

Session II: Research of Public Works/IIMI

Development of seasonal operational plans based on annual cropping plans	Busro ME
Interrelationships between main system management and palawija crop production in in dry season	H. Murray-Rust
Farm-level management of dry season water distribution in the Cikeusik Irrigation System (CIS), Cirebon Section, West Java	D. Vermillion

Session III: Research of Sukamandi/Soils Research/IRRI

P.M.

Farm Level/Productivity of Water:	Fagi
Land suitability for different cropping patterns	Abas

Friday 24 February

A.M.

Session IV: Inter-Agency Coordination

Summary of Recommendations:	Suprodjo, UGM Rosaq, UGM Fagi, Sukamandi D. Vermillion, IIMI H. Murray-Rust, IIMI
General Discussion:	Chairman: Winarno

Concluding Remarks.

P.M.

Session V: Planning for future activities

Moderator: H. Murray-Rust

List of Participants

A. Directorate of Irrigation I (DO1), Jakarta
   1. Winarno Tjiptorahardjo
   2. Soekarso Djunaedi

B. West Java Irrigation Service, Bandung
   3. Hadsan
   4. Sardjono
   5. Sukade

C. Sukamandi Research Institute for Food Crops
   6. Fagi
   7. Iis Syamsiah

D. Soil Research Institute, Bogor
   8. Suwardi
   9. Abas

E. Agriculture Department, Cirebon Section
   10. Nurcahayo

F. University of Gadjah Mada, Yogyakarta
   11. Suprodjo
   12. Sukirno
   13. Sigit Arif
   14. Mawardi
   15. Hadiano

F. IRRI
   16. S.I. Bhuiyan
   17. P. Pingali
   18. T. Woodhead

G. IIMI
   19. H. Murray-Rust
   20. D. Vermillion
   21. M.E. Busro (On secondment from DO1)
   22. Sudarmanto
   23. P.S. Rao
   24. S.M.Miranda

IIMI-IRRI COLLABORATIVE PROJECT ON IRRIGATION MANAGEMENT FOR RICE-BASED FARMING SYSTEMS

REVIEW AND PLANNING WORKSHOP
PHILIPPINE COMPONENT

20 December 1988
IRRI, Los Banos, Laguna, Philippines

P R O G R A M

0830	Opening remarks	K.J. Lampe
0840	Review of project background	S.M. Miranda
	Session I: IRRI's Research and Human Resources Development Activities	
	Moderator: D. Merrey	
0850	Farm level water control and management practices for rice and non-rice crop sequence	D.F. Tabbal
0915	Professional development and research into tillage effects and shallow groundwater resources	T. Savares M.E. Tenedora
0935	Drainage options for crop diversification in rice-lands	G.J. Moridis
1000	Coffee break	
1020	Micro-economics of crop diversification in a diversion irrigation system	P. Pingali

Session II: IIMI's Research and Human Resources Development Activities

Moderator: S. Salandanan

1100	System management study at Upper TRIS	D. Cablayan

1115	Irrigation management for dry season production of corn in rice-based systems	A.R. Maglinao
1140	A corporate strategy for the Upper Pampanga River Integrated Irrigation Systems	H. Gutierrez
1155	Management and operation of diversion type irrigation system with mixed cropping	R. Natividad
1210	Lunch	
1330	Cropping systems flexibilities and the rice-specific irrigation systems	T.B. Moya
1345	Agrohydrological characteristics of soils in rice-based irrigation systems	V.V. Babiera
1400	Water augmentation and drainage studies in irrigation systems with crop diversification	R.C. Undan

1415 Session III: Planning and Future Activities

Moderator: T.Woodhead

1530	Coffee break	
1600	Session III to continue	
1700	Closing remarks	S.I. Bhuiyan A.B. Valera

1115	Irrigation management for dry season production of corn in rice-based systems	A.R. Maglinao
1140	A corporate strategy for the Upper Pampanga River Integrated Irrigation Systems	H. Gutierrez
1155	Management and operation of diversion type irrigation system with mixed cropping	R. Natividad
1210	Lunch	
1330	Cropping systems flexibilities and the rice-specific irrigation systems	T.B. Moya
1345	Agrohydrological characteristics of soils in rice-based irrigation systems	V.V. Babiera
1400	Water augmentation and drainage studies in irrigation systems with crop diversification	R.C. Undan

1415 Session III: Planning and Future Activities

Moderator: T.Woodhead

1530	Coffee break	
1600	Session III to continue	
1700	Closing remarks	S.I. Bhuiyan A.B. Valera

LIST OF PARTICIPANTS

A. Guest

1. Dr. Klaus J. Lampe
   Director General, IRRI

B. Bureau of Soils and Water Management (BSWM)

2. Victorcito V. Babiera

3. Esperanza V. Dacanay

C. Central Luzon State University (CLSU)

4. Rodolfo C. Undan

D. Mariano Marcos State University (MMSU)

5. Rodolfo A. Natividad

E. National Irrigation Administration (NIA)

6. Maximo E. Quiming

7. Salvador Salandanan

F. Philippine Rice Research Institute (PhilRice)

8. Romeo A. de Guzman

9. Ma. Concepcion U. Toledo

G. University of the Philippines at Los Banos (UPLB)

10. Arunlfo Garcia

11. Harendra P. Srivastura

H. University of Southern Mindanao (USM)

12. Herminigildo M. Gutierrez

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