FINAL REPORT

for

STUDY ON IRRIGATION MANAGEMENT FOR CROP DIVERSIFICATION (TA 654 PHILIPPINES)

International Irrigation Management Institute
Digana Village via Kandy, Sri Lanka

December 1986

ACKNOWLEDGEMENTS

We wish to thank the National Irrigation Administration (NIA) of the Republic of the Philippines for their cooperation in conducting the studies in the main and secondary sites, and for providing useful data relating to sites, rainfall collection and topographic maps.

We wish to acknowledge the collaborative effort with the Agricultural Coordinating Division (ACD) staff of ARIP, the NIA field staff of BARIS, the officer of the MCIS Irrigation Association and the research staff of the University of Southern Mindanao (USM) in conducting studies at the Irrigation systems at a) the Allah River Irrigation Project (ARIP), Pilot Testing and Demonstration Farm No. 2, lateral A-extra; b) Banga River Irrigation System (BARIS); and c) Mani River Communal Irrigation System (MCIS).

At the Magat River Integrated Irrigation System (MRIIS), we wish to thank the NIA staff particularly the ADD staff and also the research staff of the Isabela State University (ISU) at Echague for their assistance in conducting the studies at the Isabela site.

We thank the staff of the NIA-SLBIP and the UPLB who collaborated in conducting studies relating to single-row and double-row irrigation methods and the drought and flooding (waiter-logging) tolerances of the white bean crop in the Cavite sites.

Research staff of the Department of Agricultural Education and Rural Studies (DAERS) of UPLB were commissioned as local consultants for these studies on the economics of irrigated non-rice crop production (input and output), and farmer decision making in the San Fabian River Irrigation System (SFRIS), Agno River Irrigation System (Agno RIS) (both in Pangasinan), Upper Talavera River Irrigation System (TRIS) (Nueva Ecija) and the Laoag-Vintar River Irrigation System (LVRIS) (Ilocos Norte). Research staff of the Mariano Marcos State University (MMSU) in Batac, Ilocos Norte, who helped in the survey at LVRIS.

We wish to thank the PCARRD and the staff for their cooperation in providing their facilities for IIMI's use and evaluation of the component studies undertaken by the different cooperating universities.

We are grateful to the farmers at the study areas who cooperated in many ways in pilot trials, new methods, and who took time to answer our survey questions.

We also wish to expreso our appreciation to officials and staff of the Asian Development Bank (ADB) whose interest and insights were instrumental throughout the study. The work reported in this report was made possible largely by a technical assistance grant by the bank.

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EXECUTIVE SUMMARY

INTRODUCTION

The Bank-supported IRRI-IFPRI study on "Food Demand and Supply for Developing Member Countries" concluded that Philippines has comparative advantage in the production of both irrigated rice and non-rice crops. A second phase of this study is underway to further define appropriate strategies for agricultural development for the Philippines, with special reference to the formulation of plans to achieve optimum productivity in rice and corn, with emphasis on irrigated crop diversification.

A critical issue in that study is the need to examine the technical and socio-economic constraints to profitable production of irrigated upland (diversified) crops. This became the basis for a Technical Assistance (TA 654 PHI) by the Bank to the Government of the Philippines in association with the International Irrigation Management Institute (IIMI) entitled "Study on Irrigation Management for Crop Diversification."

The Terms of Reference for this study are to.: 1) examine the constraints to irrigated crop diversification, with special attention to the irrigation management constraints; 2) examine ways in which the management of irrigation systems, particularly operation and maintenance (O&M), can overcome these constraints thereby promoting crop diversification; 3) make preliminary agronomic and economic comparisons of the different management alternatives with various crops; 4) assess O&M institution building requirements resulting from the preliminary results of the study; and 5) determine required follow-up actions recognizing that the 2-year program is limited in making definitive conclusions.

With these objectives, the IIMI staff together with local consultants (research staff of three universities) undertook the various component studies to fulfill the terms of reference. The approach used was to assess the constraints to irrigated crop diversification: irrigation, agronomic, eco'nomic, and institutional constraints. For each of the constraint camponents, corresponding studies were undertaken to provide information and data to make possible the alleviation of these constraints.

Collaboration with the IRRI-IFPRI Study on Food Supply and Demand (Phase II), was in place, particularly in studying the economic constraints. Data gathered from these studies were shared with the IRRI-IFPRI team.

This Final Report presents the study results and assessments made regarding the constraints to irrigated crop diversification. The assessments are used to justify the follow-up actions or proposed second phase of the study.

Literature Review

There are existing irrigation systems in the Philippines that have been irrigating diversified crops particularly in the dry season. Main system and farm level irrigation practices have evolved through ad hoc procedures undertaken in coping with limited water supply in the dry season. Corresponding agronomic practices in growing non-rice crops have been developed to the extent that production of these diversified crops have become very profitable for farmers.

The sources of moisture for these diversified crops are derived from rainfall, diverted river flows for irrigation, and groundwater. Information on crop-water use and production technology for diversified crops are available. However, there is a paucity or absence of information and guidelines on effective irrigation management to irrigate diversified crops for large systems in the dry season. There is a clear need to carefully study the constraints and conditions for promoting irrigated crop diversification.

IIMI's concern deals with irrigation management that will alleviate primarily the irrigation and associated factors that inhibit or constrain the promotion of irrigated diversified cropping in the service areas of systems with suitable soils during the dry season. The search for practical ways to improve the management of the main and distribution systems is the primary objective in undertaking this study.

Study Sites and Component Studies

The primary study sites were in Allah Valley (South Cotabato), Isabela, and Cavite. The secondary sites were in Nueva Ecija, Pangasinan, and Ilocos Norte. The classification of sites were based on the intensity of data collection undertaken.

Allah Valley Site. Three irrigation systems were studied at this site: a) Lateral A-extra, which incorporated the Pilot Testing and Demonstration Farm No. 2 (PTDF # 2) of the Allah River Irrigation Project (ARIP), b) Banga River Irrigation System (BARIS), and c) Mani River Communal Irrigation System (MCIS). On-farm, agronomic, and institutional studies were all conducted in the three locations. System level and economic studies were undertaken only at the BARIS and MCIS.

Isabela Site. The Magat River Integrated Irrigation Systems (MARIIS) was one of the selected study sites. Field studies were conducted particularly at the service areas at: a) SIBESTER IA area served by lateral A-3 of Division II and b) CPPL IA area served by lateral A-2-A12 of Division IV. Lateral level system study was conducted at these two locations. Other studies undertaken were on-farm irrigation methods, agronomic testing of alternative non-rice crops, economics of irrigated and rainfed non-rice crop production, and O&M practices of irrigators associations at these locations.

Cavite Site. The Second Laguna Bay Irrigation Project (SLBIP) was another site selected. A study on farm level irrigation methods for white beans was conducted, particuldrly at the Bankud River Irrigation System. A crop-water use study was also conducted in relation to the consumptive use, drought, and water-logging tolerances of the white-bean crop. However, this study was done at the UPLB experiment station at Los Banos, Laguna.

Secondary Sites. These sites were selected to provide preliminary information on existing irrigation systems operating to accommodate diversified crops in the dry season, appropriate to the literature review on irrigated crop diversification. These sites were at: a) Upper Talavera River Irrigation System (Upper TRIS) in Nueva Ecija, b) San Fabian River Irrigation System (SFRIS) in Pangasinan, c) Agno River Irrigation System (Agno RIS) also in Pangasinan, and d) Laoag-Vintar River Irrigation System (LVRIS) in Ilocos Norte. Case studies of successful irrigated non-rice crop production were also conducted on these sites.

All of these studies were made to correspond to the examination and 'assessment of the irrigation, agronomic, economic, and institutional constraints to irrigated crop diversification.

STUDY RESULTS AND ASSESSMENTS

Irrigation Constraints

On-farm level studies. The amount of water for irrigating diversified crops is actually less than rice. However, 'the volume and appropriate timing of delivery is critical. The study at ARIP, PTDF#2 showed that the irrigation of corn will be necessary when rainfall is not sufficient to provide the moisture requirements for crop growth. The availability of dry season rainfall discourages farmers to irrigate upland crops. The amount of rainfall in the dry season of 1985-86 was relatively high compared to previous years. However, in a typical year, irrigation will be necessary to obtain optimum production of diversified crop.

At the PTDF #2, irrigation of corn will require a larger lateral canal capacity to provide large volume flows at intermittent periods. The computations showed that a minimum criterion of *2.25* lps per ha will be appropriate. Moreover, for sandy soils, appropriate density and lining of main farm ditches with gated turnouts are recommended to reduce erosion and conveyance losses.

In relatively coarser textured soils, horizontal seepage of water affects the irrigation and drainage of diversified crops. Particularly in non-rice crop fields adjacent to rice paddies, seepage provides indirect irrigation. This seepage effect is influenced by the presence of a "sandstone-like" layer in the Allah Valley site. Thus, farmers are reluctant to irrigate their corn fields in abetting water-logging and to some extent avoiding payment of irrigation fees. As shown at BARIS and MCIS, irrigation through seepage is sufficient to provide the moisture needs of the corn crop.

However, a more in-depth study will be necessary to fully comprehend the extent of seepage as an irrigation alternative and its implications on the operational procedures of irrigation systems.

A comparative study on irrigation methods was conducted. Results showed that furrow irrigation method for corn was more effective in terms of shorter duration and lesser water use in comparison to the basin method. The furrow method reduced the time of irrigation to one-third that of the basin method (1 day/ha for furrow compared to 3 days/ha for basin). However, there was additional labor cost incurred for guiding the water to the furrows. Further refining the furrow method for corn, results showed that triple-row was better than double row furrow irrigation in terms of less labor use. Both methods showed the same water use and yield. In irrigating white-beans, the furrow irrigation method was found to be better than the basin method, although more labor use was incurred in the furrow method. The double-row had less water use than the single-row furrow method. These irrigation methods will only become effective when appropriate farm level facilities are in place to provide irrigation and drainage and particularly if reliable water supply is provided at the right time and amount.

System level studies. The existing practice of continuous irrigation at the system level discourages farmers to plant diversified crops. If water is delivered in sufficient quantities to grow rice, it becomes difficult to grow upland crops. Particularly at the BARIS and MCIS sites, lateral seepage affects corn fields adjacent to rice paddies. In Isabela, where water is delivered at two to three times the designed rate, the situation encourages farmers to grow rice rather than other crops. It is difficult to promote diversified cropping under these conditions and it is essential that systems are managed carefully to deliver only appropriate volumes of water to meet crop needs.

Irrigation management techniques have yet to be developed that will allow more precise deliveries of water. Results in all sites showed that irrigation is continuous in the main system of the irrigation network, enabling farmers to manage water for rice. Lack of measuring devices and inadequate control facilities make it extremely difficult to deliver large volumes of water at intermittent periods, which is optimal for diversified crops. Monitoring of water demands as part of irrigation management has yet to be established in providing appropriate water supply to crops as observed in existing systems irrigating diversified crops.

Agronomic Constraints

Testing of alternative irrigated non-rice crops. In all of the sites, most non-rice crops are grown under rainfed conditions. To promote irrigated crop diversification, several non-rice crops were tested for adaptability in an irrigated environment. Irrigated non-rice crop production technology in the primary sites was not as widespread as expected. Problems associated with appropriate timing of non-rice crop cultivation were encountered in this study. Late planting of crops resulted in low yields. This was due to the vulnerability of crops to the build up of pests and diseases and also to the sensitivity to high temperatures (in the case of pod formation in the white-been crop). However, optimum production and profitability can be attained if appropriate crop care practices are adopted. At the Allah Valley and Isabela site, irrigated hybrid corn and peanut crop production showed potential for adoption. At the Cavite site, irrigated white-bean production results indicated successful adoption only when appropriate crop care technology and extension support are provided.

Crop-water use of selected diversified crops. Corn and white-bean crops were studied for their crop-water use Characteristics. Moisture-sensitive stages of crop growth were identified. For corn, optimum water use was shown to be effective for grain yield when irrigated at the tasseling and grain formation stages for shallow water table areas. For the white-bean crop, sensitivity to water logging was shown to occur at the early to vegetative stages while drought affected the reproductive stage.

There is widespread unfamiliarity with non-rice crop production under irrigated conditions. At the Allah Valley, corn is grown under rainfed conditions or through seepage from adjacent rice fields. In drier areas, there is some acceptance of irrigated crop diversification, but in areas with significant dry season rainfall, the benefits of irrigated non-rice production still have to be demonstrated. Timing of non-rice crop cultivation is important because the factors of temperature, incidence of pests and diseases, and risk of waterlogging through heavy rainfall are critical. The results from Cevite show that agronomic constraints can be mitigated with appropriate extension efforts.

Economic and Institutional Constraints

The profitability of irrigated rice and non-rice crops were comparatively assessed. At the BARIS site, the returns to irrigated rice production was higher than that to irrigated corn. This can be attributed to the higher yield and market price of rice compared to corn. Moreover, input cash costs relative to yield were observed to be higher for corn than rice. This is due to lower production levels of corn. Comparing irrigated and rainfed hybrid corn, irrigated corn production was higher than that of rainfed corn. The difference was not pronounced due to the rainfall that occurred in the dry season which masked the effects of irrigation on corn.

The market availability and price of non-rice crops were not stable enough to encourage irrigated non-rice crop production. At the Isabela site, farmers were very responsive to the market price of non-rice crops. The unstable market price of corn discouraged farmers from shifting away from rice in the dry season. Indirect incentives like reduced irrigation fees and non-payment of land rent for tenants can be considered as ways of promoting irrigated crop diversification.

The main economic constraints found were unfavorable market prices and high input costs for non-rice crops. Where market prices are assured and stable, crop diversification can be attained. In Isabela, the unstable price of corn exacerbated farmers' reluctance to adopt non-rice crops. Similarly, in the Allah Valley site, the comparatively low price of non-rice crops was perceived by farmers as the leading problem in crop diversification.

The institutional component studies conducted showed that the operations of the communal system were no better than the NIA systems. The disregard of farmers for irrigation schedules resulted in inequitable distribution favoring the upstream farmers in both BARIS and MCIS. There was an observed discrepancy on what was perceived and practiced by the farmers with respect to their responsibilities to the irrigators association (IA).

Perceptions on responsibilities ranged from payment of fees, meeting attendance, and adhering to rtgreed upon policies and decisions. In practice, a majority regarded maintenance or group work as the most important responsibility. However, the overriding consideration in making the IA viable is the farmer members' perceived benefit in joining the IA; the primary benefit sought is sufficiency of irrigation water. Communication between farmers and system operators have to be improved if uncertainty over water delivery schedules is to be reduced. Adherence to the irrigation schedule has to be practiced instead of just being agreed upon.

Ways to improve on the communication between the farmers and the system operators for the implementation and adherence to water delivery schedules have to be investigated to fully utilize the capabilities of the IAs. Studies to improve on the joint management of IAs and NIA need to be conducted to attain better communication and reduce farmers' concern on the uncertainty of water delivery schedules.

SUMMARY AND RECOMMENDATIONS

Irrigation Water Management

The study showed that to effectively irrigate diversified crops larger canal capacities have to be considered particularly in sandy soils areas. However, existing rice gravity systems can accommodate these large volume and intermittent demands by extertding the water delivery periods provided appropriate control and monitoring of water deliveries are undertaken. The absence of established guidelines in operating systems makes it difficult to irrigate diversified crops in the dry season. Studies to arrive at effective procedures in irrigating non-rice crops have to be conducted.

On-farm irrigation facilities require modifications to provide the proper moisture conditions for diversified crops. Continuous flows of irrigation water result in water-logging; more so when the effects of seepage are taken into consideration. The effects of seepage on irrigation and drainage of crops have to be investigated further. To overcome these constraints, it is recommended that irrigation deliveries be rescheduled to provide large and intermittent volumes to speed up irrigation from 3 days to 1 day per ha. To attain this, it will require additional investigations in determining optimal ditch density of farm irrigation and drainage ditches and development of less erodible farm channels. Farmers should be shown how to adopt furrow irrigation rather than basin flooding to speed up the time of irrigation, provide more uniform water, and apply less water on their farms.

Agronomic Practices for Irrigated Diversified Crops

Unfamiliarity with irrigated non-rice crop production technology is widespread particularly in the primary sites. Timing of cultivation for diversified crops is particularly important when there are factors such as temperature, incidence of pests and diseases and risk of water-logging through heavy rainfall. In areas where there is dry season rainfall, a greater effort has to be made to demonstrate the benefits of irrigation on diversified crops, especially in the timing of irrigation in relation to the growth stages of the plant, and the need to determine when irrigation is needed to avoid moisture stress. This must be supported by irrigation management more responsive to crop water requirements. It is recommended that more emphasis be placed on studies to alleviate the agronomic constraints so that production can be raised to levels which are attractive to justify additional input costs such fertilizer, seeds, pesticides, crop care, and irrigation.

Economic and Institutional Aspects of Irrigating Diversified Crops

The unstable prices and high input costs of non-rice crops were identified as the factors inhibiting farmers to adopt irrtgated diversified cropping. Profitability of non-rice crop production is the foremost consideration of farmers in irrigated agriculture. Where market prices are assured with comparable stability to rice prices, there is clear evidence that crop diversification can be achieved. In order to mitigate the constraints to marketing problems for non-rice crops, it is recommended that investigations on the market structure and post-harvest facilities be undertaken. Other indirect incentives such as reduction or removal of irrigation fees should be further studied.

Better communication between the farmers and the systems operators have to be established. This will reduce the concern on uncertainty of water delivery schedules particularly for irrigating diversified crops requiring large and intermittent volumes of water Studies on the joint management of systems between IAs and NIA have to be undertaken to fully utilize the capabilities of organizations in providing effective irrigation service to the farmers.

PROPOSED PEASE II STUDY ON IRRIGATION MANAGEMENT FOR CROP DIVERSIFICATION

Rationale

The results of the initial study showed that there are important technical and socio-economic aspects *to* irrigation management for diversified cropping which are not understood, and which exert a profound effect on the profitability of cultivation and the return on investment in irrigation. Several constraints to succesiful diversified cropping in irrigated areas were identified, together with suggested ways to mitigate those contraints.

These results must be considered preliminary, however, due to the limited study period *(22* months and only one dry season) during which the study was conducted. This period was understood at the outset as sufficient only to open up the issues for further study with sharper focus, and to establish administrative and substantive relationships at several field sites which could lead to conclusive results over a longer period. To capitalize on the investment in the Phase I Study, a more detailed study is needed.

The Study Advisory Committee (SAC), comprising representatives of three Philippine Government agencies (National Irrigation Administration [NIA], Ministry of Agriculture and Food [MAF], and the Philippine Council for Agriculture and Resources Research and Development [PACRRD]), the Bank and IIMI, strongly endorsed the extension or second phase of the study at its 13 August 1986 meeting. To ensure that the study contribute to the larger goals of agricultural productivity in irrigated areas of the Philippines, the Committee recommended that priority be given to the extension of studies on a) managing the main and distribution network of irrigation systems, b) on- farm irrigation methods and facilities, c) agronomic practices, and d) economic and institutional aspects of irrigated crop diversification.

Objective

The primary objective of the Proposal is to determine those irrigation practices most likely to enhance the cultivation of selected non-rice crops in limited parts of irrigation systems during the dry season, and to field-test the most promising of those practices in selected commands.

Associated objectives are to:

1) Develop a criteria or methodology for identifying those parts of irrigation commands with comparative advantage for selected diversified crops;

2) Compare the profitability of selected diversified **crops** under irrigated and rainfed conditions, and to compare their irrigated performance with that of irrigated rice;

3) Determine the primary factors and their interaction which condition how farmers prepare land for irrigated rice in the wet season and for one or more diversified crops in the dry season;

4) Develop on-farm irrigation methods for at least one upland crop;

5) Design and field-test operating procedures for publicly-managed portions of irrigation systems; and

6) Recommend those policies likely to support more profitable farming practices and more profitable investment in irrigation development as related to diversified crops and arrive at guidellnes on irrigation management practices €or diversified cropping.

Proposed Sites

The studies will be conducted at seven irrigation systems on Mindanao and Luzon Islands. All three systems selected in Mindanao were included in the Phase I Study. Some Phase I work was carried out in the Luzon systems too, but the Phase II proposal envisages an extension of the work to include both Mindanao and Luzon with roughly equal weight.

On Mindanao Island:

a) Allah River Irrigation Project (ARIP),
b) Banga River Irrigation system (BARIS), and
c) Mani River Communal Irrigation System (MCIS);

On Luzon Island:

a) Bonga Pump #2 (Bonga River Irrigation System Pump No. 2) or a similar pump system,
b) Laoag-Vintar River Irrigation System (LVRIS),
c) Upper Talavera River Irrigation System (Upper TRIS), and
d) Tarlac-San Miguel-O'Donnel River Irrigation system (TASMORIS).

These systems provide a range of climatic and soil conditions representative of the two most important irrigated regions of the Philippines. Their selection was based on many factors including the availability of NIA field and counterpart staff who will assist in carrying out the studies.

Implementing Arrangements and Reports

The executing Agency for this Technical Assistance Phase II Study will be the International Irrigation Management Institute (IIMI). IIMI will carry out the studies in close collaboration with the National Irrigation Administration (NIA) which is the lead government agency, together with the Philippine Council for Agriculture and Resources Research and Development (PCARRD) and the Ministry of Agriculture and Food (MAF).

NIA will be the lead agency for the two irrigation projects and other irrigation systems in which the study sites will be located. NIA will also be the executing agency for agricultural development in ARIP, while for the others the NIA irrigation systems offices will be the cooperating agencies. MAF will also be a cooperating agency in respect of trials with vegetables. Studies involving crop production in all of the selected study sites will be carried out in close coordination with the lead research agencies of the PCARRD consortium. These agencies are the University of Southern Mindanao in Kabacan for ARIP, BARIS and MCIS; the University of the Philippines in Los Banos; the different state colleges and universities under the Central Luzon Agricultural Research Center in Munoz for the Upper TRIS and TASMORIS; and the Mariano Marcos State University in Batac for the Laoag-Vintar RIS. It is intended that the component studies be conducted in association with IIMI. The research studies in the Phase II Study will be included in the annual review and evaluation being conducted by PCARRD as part of its regular coordination of agricultural research projects.

The IIMI Coordinator for the Phase I Study or his replacement will direct and coordinate the Phase II Study Implementation. The IIMI local (Philippine) staff will continue to carry out on-site studies and data collection for each of the selected study sites. These include on Research Associate and four Research Assistants. Consultants and research assistants will be hired as needed to supplement this manpower. IIMI will provide a consulting Agricultural Economist at the International level to coordinate and provide guidance to the economic studies. Some research staff from the cooperating agencies or universities belonging to the PCARRD network of research consortia will be engaged as local consultants. To facilitate implementation, NIA will continue to provide site office accommodation and assistance in data collection through its field personnel.

The Phase II Proposal is planned for a 29-month period commencing January 1987. However, in order to cover three dry seasons within this period, data collection will begin in November 1986 which is the beginning of the dry season in most of the study sites.

A first or initial progress review report will be presented by IIMI after 8 months, a second progress review report after 14 months, an interim report after 18 months, a workshop report after 22 months, a draft final report after 28 months, and a final report on completion of the 29-month period.

Cost Estimate

The cost of the proposed Phase II Study technical assistance is estimated at $415,000 of which $350,000 will be financed by the Bank and $50,000 by IIMI and $15,000 by NIA. There will be no incremental counterpart funding required from the Government; however, as noted above, NIA staff already employed at the project sites and in related research activities will assist and cooperate in the study and NIA will provide site office accommodation. These activities will not involve additional expenditure by the government. The contribution of NIA will be the notional costs of collaboration with respect to the existing facilities and staff expected to assist in the implementation of this Proposal.

Since there will be a two-month (November and December 1986) advance on start-up time in 1986 for this first dry season activities, IIMI will provide interim support during this period contingent upon the Phase II Proposal being funded beginning January 1987.

IRRIGATION MANAGEMENT FOR CROP DIVERSIFICATION[1]

I. BACKGROUND

1-01 In recent years, developing countries growing irrigated rice crops have attained relatively consistent levels of self-sufficiency. The growing of diversified crops on lands currently allocated to irrigated rice in the dry season emerges not only as an important alternative for optimizing land and water use for increased agricultural production but also as a challenging area in irrigation management as how best to manage water under different conditions related to climate, soil and existing irrigations systems.

1-02 Several studies conducted in the Philippines have established the fact that diversified crops use significantly less water than rice at the farm level. The total water supply for rice under continuous flooding (at 10 cm) and relatively heavy soils, amounts to 800-1,000 mm, (De Datta, 1981), while the range for diversified crops are from 300 mm for bush beans to 600 mm for corn (Table 1.1). The works of Tabago (1977), Tabanao (1977), Gumtang (1984) and del Rosario et.al., (1985) among others, indicate the availability of information and data on water use of diversified crops in the Philippines.

1-03 Because diversified crops require less water than irrigated rice, there is a recognized potential for increasing agricultural production through optimal use of limited water. Past experiences however, have shown that while there is promise in this area, not all the factors that contribute to the success of growing diversified crops have been fully understood. Early programs such as the Angst-Magat Integrated Agricultural Development Project (AMIADP) conducted in 1973, faltered on marketing problems especially for the soybean and sorghum crops, and that program was discontinued in 1975. Farmers preferred to grow irrigated rice instead.

Climate

1-04 In the Philippines, irrigated crops depend on two sources of moisture; rainfall and diverted river flows. The rainfall pattern in the Philippines can be categorized into four *(4)* rainfall types namely (Fig. I. 1):

Type I. Two pronounced seasons. Dry from November to April and wet during the rest of the yesr. This type covers the regions of Ilocos, Central Luzon, Northwest Mindoro, Northwest Palawan, Antique, Aklan, and Negros Oriental.

Type II. No dry season with very pronounced maximum rainfall from November to January. This covers the Western part of Southern Tagalog, Bicol region, most of Leyte, Eastern Samar and Eastern Mindanao.

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1 Final Report for T.A. 654 PHI submitted to the Asian Development Bank (ADB) by the International Irrigation Management Institute (IIMI) December 1986.

Type 111. Season not pronounced with relatively dry from November to April and wet during the rest of the year. This covers Nueva Viscaya, Isabela and Cagayan, Masbate, Capiz, Negros Occidental, Southern Cebu, and some provinces in Central Mindanao and Southern Zamboanga.

Type IV. Rainfall more or less evenly distributed throughout the year. This covers Eastern Mindanao, Western Bicol, Northern Cebu, Western Samar, Bohol and Southwest Mindanao (Hernandez, 1971).

In the wet season, irrigation generally supplements rainfall while in the dry season it is the main source of water. For diversified crops with deep rooting characteristics (e.g. corn, sorghum, cotton) sub-surface water sources play an important role especially in the dry season. Drainage considerations for these crops are also influenced by groundwater sources.

Project Objectives

1-05 A technical assistance (T.A. 654 PHI) was granted by the Asian Development Bank (ADB) to the Government of the Republic of the Philippines. This technical assistance entitled "Study on Irrigation Management for Crop Diversification" was implemented by the International Irrigation Management Institute (IIMI). The general objective was to identify technical and socio-economic constraints to irrigated crop diversification with special attention to: 1) irrigation management constraints to crop diversification, 2) agronomic and economic comparisons of different irrigation management alternatives, 3) assessment of Lnstitutional aspects relating to crop diversification, and 4) general implications from the above findings.

Study Sites

1-06 The study sites are located in three major regions of Philippines: the Isabela site in the northeast, the Allah Valley in the south, and the Cavite site in the central region (Fig 12). In addition to the three sites selected, four other sites were added to gain insight and provide information on factors that contribute to successful crop diversification. They are: the Upper Talavera River Irrigation System (Upper TRIS) in Nueva Ecija; Agno River Irrigation System (Agno RIS) and San Fabian River Irrigation System (SFRIS), both in Pangasinan, and the Laoag-Vintar River Irrigation System (LVRIS) at Ilocos Norte.

Component Studies

1-07 Several component studles were undertaken to provide a multi-disciplinary package; these included monitoring of irrigation system management and on-farm water management practices of farmers, agronomic crop management practices and plant-laoil-water relationships, economic comparisons of irrigated and rainfed non-rice crop production, and institutional aspects such as observing IAs and farmer behavior in irrigation management.

1-08 Collaboration with the IRRI-IFPRI Study on Food Supply and Demand Phase II focused on the economic constraints. Data was shared with the IRRI-IFPRI study. Due partly to lack of equipment and the heterogeneous planting of rice and non-rice crops in the selected study sites, the economics of overhead sprinkler was not attempted.

1-09 Survey of Irrigation Management Practices. The operation and maintenance practices of four NIA systems were surveyed and facilities for irrigating dry season diversified crops were preliminarily evaluated. These were the Upper Talavera River Irrigation System (Upper TRIS) in Nueva Ecija; Agno River Irrigation System (Agno RIS) and San Fabian River Irrigation System (SFRIS), both in Pangasinan, and the Laoag-Vintar River Irrigation System (LVRIS) at Ilocos Norte.

1-10 At the Upper TRIS, although the entire dry season service area (500 ha) was scheduled for irrigated diversified crops, some farmers persist in growing rice in the upstream and low lying areas. In most years, only 50-60% (approximately 200-300 ha) of the programmed area actually grows diversified crops.

1-11 Continuous irrigation is generally practiced in this system. But during times of water shortage the non-rice crops receive priority on a rotational schedule. Because there are few control structures and virtually no guidelines in operating the system for diversified crops, fanners have evolved their own on-farm irrigation practices. The irrigation method used can be described as "Basin-Flush-Flooding." Rice paddy configurations are maintained with paddy dikes. Onion and garlic are grown in either mulched plots or raised beds. For the mulched plots, ditches are constructed on the inside edges of the paddy bouncaries. Flooding and draining is accomplished with these as perimeter ditches. For the raised beds (1-1.5 m wide), ditches are made in between beds to serve as irrigation and drainage ditches. The assistant water management technician (AWMT) from NIA is responsible for providing irrigation water up to the turnouts and enforces rotational schedules in times of water scarcity.

1-12 At the Agno RIS, only 20X of the service area is programmed for diversified crops such as mungbean, cotton, tomato, and tobacco. The production of irrigated cotton and tomato are contracted with the Philippine Cotton Corporation and Tomato Paste Factory. For these two crops, irrigation water is assured due to guaranteed payment of irrigation fees through these agencies. Moreover, they are planted in the upstream portions of the system. In contrast, tobacco and corn are planted sparingly in relatively elevated portions adjacent to rice areas, while the mungbean fields (approx. 200 ha) are located at the tail end portion of the system.

1-13 Continuous irrigation is practiced but when water is short, it is rotated by sections of the main and lateral canals. Because there are no control gates in the canals, fanners tend to provide their own materials for checking (raising the water elevation in the canals).

1-14 The tail end of the system (mungbean area) is totally dependent on additional water being diverted as released from the hydroelectric dams at Ambuklao and Binga into the Agno river. Since there is no fixed or reliable schedule for water releases, farmers have tended to evolve ad hoc procedures for irrigation to their mungbean crops.

1-15 At the farm level, basin-flush-flooding (temporary ponding until all portions of the paddy are saturated) is practiced. The paddy dikes are retained from the previous rice crop to impound the water which is later drained into the next paddy. Thus, a form of paddy to paddy irrigation is used by farmers to manage limited water supplies.

1-16 At the San Fabian RIS, the yearly dry season water supply determines the actual total area to be irrigated. The NIA staff makes the annual wet and dry season irrigation schedules and inform the farmers during fee collection. For heavy rice soils, irrigation water duty is computed at 1.5 lps/ha by the NIA staff and for coarser textured soils the water duty is 2.5 lps/ha. Of a total area of 1,383 ha in dry season area, about 884 ha is planted to tobacco and the rest to rice. The main reason for the larger area for tobacco is because of coarser textured soil in the service area which would require a larger water duty if planted to rice.

1-17 Continuous irrigation is practiced in the wet season. However, in the dry season, a rotational schedule is implemented due to limited water supply. The system is divided into sections based on hydrologic boundaries and water availability. Rotation is done by laterals or sections of the main canal. The staff gages installed at the main canal and lateral headgates are rarely calibrated, so estimated water flow is based on the experience of the NIA field staff and a weekly rotation to each section proportional to the area and crop grown is implemented.

1-18 As in the other areas, control gates in the main and lateral canals are absent. Checking is done on an ad hoc basis by farmers using flashboards or tree trunks.

1-19 On-farm level irrigation of tobacco is done using the basin-flush-flooding method (described in 1-15). In flatter areas and in larger paddies, additional farm ditches are ccnstructed for delivering water to each paddy. Simultaneous openings in the Faddy dikes are made to hasten irrigation delivery and prevent water logging. Additional ditches are also made to drain excess water to other paddies.

1-20 The Laoag-Vintar RIS is divided into two portions. The upstream portion serving the Vintar area has continuous wet and dry season irrigated rice. The downstream portion serving the Laoag-Bacarra-Sarrat (LABASA) area, has wet season irrigated rice and dry season irrigated diversified crops. With limited dry season water supply, a total area of only 1,800 ha is irrigated. About 700 ha is planted to diversified crops and the rest to rice.

1-21 The Vintar IA is not functional since the farmers can easily get their water due to their favored upstream location. In contrast, the LABASA IA is more active since the farmers need to cooperate to effectively use the scarce water supply to their area.

1-22 The LABASA IA area is divided into two zones. Each zone is managed by one water master who is responsible for water distribution. Each zone is sub-divided into districts, and the IA officers and members come from these zones and districts. Irrigation planning and scheduling is done jointly by the LABASA IA and NIA staff two weeks before the start of the season. In the dry season, areas for irrigated rice and diversified crops are based on the land classification. In the IABASA area, about 90% of the land is planted to diversified crops (garlic, mungbean, and other vegetable crops).

1-23 The water master implements the schedule based on rotation by district. The officers of the LABASA IA help the water master in implementing the schedule. Weekly irrigation water is supplied for coarser textured soils and every other week for clay soils. Where there is acute water shortage, priorities are decided by the district officers and LABASA Board of Directors in cooperation with the NIA field staff and schedules are adjusted according to crop needs.

1-24 As in the San Fabian RIS, the staff gages at major canal points are rarely calibrated and farmers have generally evolved their own methods of irrigation practices on an ad hoc basis.

1-25 The field or on-farm level irrigation practices for diversified crops are carried out by impourding water within the paddy plots. An actual survey of the main farm ditches in the LABASA IA service area gave a mean of 108 m/ha of farm ditch density. The relatively undulating topography in the service area (mean slope 1%) allows the paddy to paddy flow of water during irrigation even for diversified crops. Basin flooding is practiced, as in the other areas. The small farm size (0.5 ha) enables, in some cases, a 300% cropping intensity.

1-26 <u>Farmers' Decision Making Processes</u>: A study of cases of successful irrigated crop diversification was conducted, to provide insights into farmers' decision making process to grow irrigated non-rice crops in the dry season. The physical factors (i.e., irrigation, soil, and crop production technology) were taken into account together with the financial profitability and the associated crop input and output requisites (credit and marketing). This study was conducted in the four (4) irrigation systems. Highlights of the results for 4 crops (tobacco, cotton, onion and garlic) are presented in this report.

1-27 A total of 40 farmers for each crop were interviewed regarding their expectations and actual farming performance. Responses on the perceptions regarding sufficiency of irrigation water for rice indicated that farmers have a fairly accurate assessment of water availability during the dry season. At the SFRIS, where water supply is limited in the dry season, only a third (33%) of the sample farmers surveyed indicated the sufficiency of water for rice (Table 1.2). Out of this portion that perceived sufficiency only **39%** actually planted rice. However, more than half **(59%)** of the farmers responded that given sufficient water, they will plant rice. This indicates that farmers prefer to plant rice than tobacco if water is sufficient.

1-28 At the Agno **RIS**, for those sampled farmers who indicated a perceived sufficiency of water for rice more than half **(53%)** planted rice (Table ***1.2).*** The sampled farmers in this system were located in the upstream portion. Among those farmer who did not expect water sufficiency for rice, all 10 respondents (100%) said they would not plant rice even if water was made available to grow rice (Table I.2). At the Upper TRIS, the responses were not **as** clear cut regarding growing rice if sufficient water were available. However. more than half (58%) preferred to plant non-rice crops.

1-29 A comparative assessment was made regarding input cash costs, family labor, and profitability between diversified crops and rice. For tobacco, the input cash costs was not very much higher than rice (Table 1.3). However, the family labor was five times **as** much **as** that for rice. The profitability was three times **as** much compared to rice. Tobacco is **grown** as a cash crop with an assured market (Table 1.4). More than half of the sampled farmers were also provided with credit by the buyer. This in effect provides an added incentive to plant tobacco. The reason farmers gave in preferring tobacco among other crops was the profitability and familiarity with the production of tobacco.

1-30 For the cotton crop, a well-structured production, credit and marketing program leading to a profitable outcome is the main reason for its adoption by farmers in the Agno RIS. Despite moderate input costs and family labor input, profitability is still attractive, considering the cash inputs and marketing assurance incentives provided (credit and marketing of produce is assured by the Philippine Cotton Corporation). However, the main drawback of producing cotton is the absence of immediate cash returns (Tables **1.3** and I. *4)*.

1-31 **Onion** production at Jpper **TRIS**, has the highest input cash requirements, family labor, and **also** profitability among the crops presented (Table **1.3).** With **no** assured market nor source of credit, onion production is more risky compared to tobacco, cotton or rice but the profits are high (Table ***1.4).*** This crop is more vulnerable to market conditions prevailing after harvest, indicating the fragmented market structure that beset this crop.

1-32 Garlic production **in LVRIS** has the highest seed cost and family labor requirements (Table **1.3).** Like Onion production, it is **also** a high risk crop because there is no assured market nor source of credit. It is also vulnerable to market conditions prevailing after harvest (Table ***1.4).***

1-33 Conditions suitable for successful adoption of irrigated diversified cropping can be enumerated based on the cases reviewed in these systems namely: a) limited water supply; b) limited income opportunities from other sources of livelihood; ***c)*** observed profitability from neighboring farmers who diversified; d) family's rice consumption requirement fulfilled for the year from the wet season cropping; e) the production of the crop is perceived as technically feasible to grow (suitable soil and topography, familiarity with the crop technology, and water availability); f) availability of seeds; g) the crop is perceived as economically viable (presence of market, sources of credit if needed and labor); h) the farmer is convinced that the crop will significantly provide higher returns than rice; and i) the market price of produce is relatively stable or assured as in the case of "contract farming" with appropriate companies.

1-34 One factor that needs attention is the paucity of information on how irrigation systems can be effectively managed for optimazation of diversified cropping. Information on crop water use are established and crop production technology is in place. However, if existing irrigation systems are to be effectively utilized for increasing productivity in the dry season, attention should be geared towards the management of these systems.

1-35 Plusquellec and Wickham **(1985)** sum up the problem of diversified dry season crops as requiring less water than rice, but greater control over the water. Dry season water is insufficient to irrigate most of the project areas, but control and management in both the system and on-farm levels are even more limiting at present. In considering possible non-rice crops for the dry season, farmers evaluate primarily the prospects of profitability and adequate water control, periods and intervals of availability, reliability of supply, stream size, and protection from over-irrigation, €or example, and only secondarily the amount of water.

1-36 Profitability of upland farming is also jeopardized, at least in the short run, by the absence of guidelines on how large system should be operated to supply water for dlversified crops. Water management recommendations are usually based on potential water requirements and on-farm distribution methods which are largely irrelevant in systems which are operated without positive gate control at the outlets and without predictable intervals of irrigation followed by no irrigation.

1-37 Land improvements necessary for converting first-class rice land to productive upland crops are a) creation of a series of beds **4** to 5 meters wide separated by ditches to raise the elevation of the land, b) land consolidation which increases the surface drainage, irrigation and road networks, and c) flood embankments in some cases to keep out excess water and to protect the surface networks.

II. STUDY SITES AND CORRESPONDING STUDIES

Allah Valley Site

2-01 There are three irrigation systems at this site: 1) Allah River Irrigation Project (ARIP), Pilot Testing and Demonstration Farm No. 2, Lateral A-extra; 2) Banga River Irrigation System (BARIS); and 3) Mani River Communal Irrigation System (MCIS).

2-02 ARIP, PTDF#2, Lateral A-extra. Component studies were conducted in service area of ARIP, at Lateral A-extra with a command area of 277 ha, the site for the PTDF #2 (Fig. II.1). Although not considered an ideal site because of porous (sandy) soil with portions of undulating terrain, the availability of irrigation water from the DAM I of ARIP at the onset of the study in October 1985 was a major factor for its selection as a pilot site.

2-03 The studies included: a) a water management scheme for Lateral A-extra (including improvementn on farm level irrigation facilities) for irrigating non-rice crop during the dry season; b) evaluation of furrow and furrowed-basin irrigation methods; c) testing of alternative irrigated non-rice crops (mungbean, peanut, and improved open-pollinated corn); and d) an agro-socio-economic profile of the farmers.

2-04 A simulation of irrigating corn based on a 18-year rainfall record to demonstrate the needs for irrigation on hybrid corn during the dry season was also undertaken.

2-05 Banga River Irrigation System (BARIS). In order to study irrigation system management for crop diversification on an existing system, the BARIS was selected (adjacent to ARIP Fig. 11.1). The BARIS is a run-of-the-river type irrigation system with a command area of 1,930 ha. The dominant problem in this system is the high amount of silt contained in the river flow. O & M procedures are being undertaken to alleviate this problem. One outstanding feature of this system is the participation of the IA in the water allocation, scheduling, and implementation decisions in operating the system. For more details on this see Annex 1.

2-06 In addition to the irrigation system management study whereby monitoring of O & M procedures were undertaken, other component studies were also conducted in this system. These studies were: a) economic study on the profitability of different cropping pattern; b) testing of alternative irrigated non-rice crops (mungbean, peanut, and improved white open-pollinated corn); c) evaluation of furrow and furrowed-basin irrigation methods; and d) agro-socio-economic profile study of BARIS farmers.

2-07 Mani River Communal Irrigation System (MCIS). A comparative study on irrigation system management between a NIA managed system and a farmer managed communal system (MCIS serving 700 ha) was conducted. This system derives its water source from a concrete diversion dam across Mani River located in Esperanza, Koronadal, South Cotabato. NIA provided financial and technical assistance in improving the physical facilities of this system. Each farmer is a member of the IA in the area. The operational details of the system can be found in Annex 2.

2-08 Besides the study on irrigation system management at this system other studies were also conducted. These studies were: a) horizontal and spatial distribution of soil moisture or seepage effects for irrigation; b) testing of alternative irrigated non-rice crops (mungbean, peanut, and improved open-pollinated corn); c) evaluation of furrow and furrowed-basin irrigation methods; and d) agro-socio-profile of farmers.

Isabela Site

2-09 The Magat River Integrated Irrigation Systems (MARIIS), formerly the Magat River Multipurpose Project (MRMP) has a storage reservoir dam with a command area of 97,000 ha in the wet season (Fig. 11.2). In the 1985 dry season, the actual area irrigated was 74,445 ha. Approximately 11,000 ha of its service area is classified as having soils with dual and diversified land classes. The land classification was based on the textural type, water-holding, and productivity characteristics. For the first class rice soils, the textural type is clay with an estimated seepage and percolation rate of 3 to 5 mm/day. For the dual land class, the textural types ranges from clay loam to sandy loam with a seepage and percolation rate of about 5 mm/day. For the diversified land class, the textural types range from sandy loam to sand with a seepage and percolation rate of more than 10 mm/day. About 70% of the dual and diversified land classes at MARIIS command area (11,000 ha) are found at the service area Division II in the towns of San Mateo and Cabatuan. The other locations are found in Division IV service area. These soils are commonly referred to as belonging to the Lateral A series service area of MARIIS.

2-10 Field studies were conducted at: 1) Sibester IA area served by Lateral A-3 of Division II; and 2) CPPL IA area served by Lateral A-2-A12 of Division IV.

2-11 A study on the system level management was conducted in the above laterals. Other component studies were also conducted at these two field sites. These were: 1) evaluation of two irrigation methods for corn (double row vs triple row furrows); 2) crop testing of alternative irrigated non-rice crop (peanut); 3) economic aspects of irrigated/non-irrigated crop diversification; and 4) a study on the operation and management of the irrigation associations at these field sites.

Cavite Site

2-12 The Second Laguna de Bay Irrigation Project (SLBIP), expected to be completed in 1988, will irrigate about 13,160 ha in the wet season and 9,600 ha in the dry season. Approximately 2,500 ha is programed for vegetable production as part of an increase in irrigated area made possible by pumping water from Laguna de Bay in the dry season.

2-13 The proximity of Cavite to Manila (approximately *40* km south) favors the marketing of vegetables. Moreover, the relatively heavy or finer (clay) soil type can be used for vegetable production through raised beds and ridges. The rainfall pattern is characterized by distinct wet and dry seasons. The wet season starts in May and ends in October. The dry season usually starts in November and ends in April. With these geographic soil and climatic conditions, vegetable production is a logical choice for irrigated crop diversification.

2-14 The **NIA** and MAF conducted a program to promote white bean production as part of a development effort to utilize the planned ***2,500*** ha for vegetable production at SLBIP. This program led IIMI to conduct studies relevant to the production of white beans.

2-15 The conducted studies evaluated the single-row and double-row furrow irrigation methods and the drought and flooding (water-logging) tolerances of the white bean crop.

Secondary Sites

2-16 In addition to the three sites selected for this study, four sites were added to gain more insight and provide information on irrigated crop diversification. However, the intensity of data collection at these sites was less than that of the main sites. These sites were at the San Fabian River Irrigation System (SFRIS), Agno River Irrigation System (Agno RIS), both in Pangasinan, Upper Talavera River Irrigation System (TRIS) (Nueva Ecija) and the Laoag-Vintar River Irrigation System (LVRIS) (Ilocos Norte).

2-17 These irrigation systems operate under favorable conditions for irrigated crop diversification because no rain is expected from October to April in the dry season. With this rainfall pattern, irrigation water from river flows consequently decreases in the dry season. About half ***(50*** to 60%) of the service area is programmed for rice irrigation, with the remaining area programed for non-rice crops (tobacco, garlic, onion, mungbean. and cotton). The soils are suitable **for** upland crop cultivation, ranging from' clay loam to sandy loam. Farmers have long practiced crop diversification in the dry season and have developed considerable familiarity with irrigated non-rice **crop** production techncloqy.

2-18 This study focused on the economics of irrigated non-rice crop production (input and output) and farmer decision making aspects of irrigated crop diversification. O&M procedure at these sites was also surveyed. Of particular interest are the conditions that have made irrigated crop diversification successful. Limited irrigation water supply, no rainfall, soil suitability, familiarity with irrigated non-rice production technology and favorable market conditions among others all combine to provide a suitable environment for irrigated diversified cropping.

III. CONSTRAINTS TO CROP DIVERSIFICATION

Irrigation Constraints

3-01 On-Farm study results. At PTDF#2, water supplies were derived from the flows of Lateral A-extra hesdgate and available rainfall. There are wet and dry seasons depending on the relative amounts of rainfall occurring in particular periods within the year. Thus the wet season is from May to November and the dry season froa December to April (Fig. 111.1). The 1985-86 rainfall pattern was relatively wet compared to the mean of 18-year rainfall data in this site. This rainfall record was obtained from a station approximately 20 km. from the site. Cumulative 20 percent, 50 percent, and 80 percent probabilities were computed using the incomplete gamma function (Fig. 111.1).

3-02 Field measurements showed that the actual Lateral-A-extra discharge (500 lps) is larger than the designed discharge (391 lps). Crop environmental demands were compited based on the evaporation and seepage and percolation (S & P) measurements. Evaporation at this site ranges from 3-6 mm/day while the S & P is about 10 mm/day.

3-03 The estimated S & P value is relatively low for sandy soils, due to the presence of a semi-permeable layer of "sandstone" like material in this site. This layer has thickness ranging from 5 cm to 20 cm. The depth of this layer from the surface ranges from 0.5 m near the highway and 1.5 m near the river. The mean depth in tie fields measured is about 0.8 m. It was also observed that this layer follows the land surface topography. The main effect of this layer is to significantly retard the downward flow or percolation of water resulting In the relatively low S & P measurements and impounding of water in the low portions of the Lateral A-extra service area.

3-04 With the physical parameter determined, coupled with the farmers expressed preference (through survey), a rice-corn-legume cropping pattern was proposed. This was discussed at meetings with farmers and the ACD staff of NIA-ARIP. However, only the water delivery schedule for the rice and corn crops is presented in the completed study report (Annex 111).

3-05 Through a simulation model, alternative irrigation schedules for irrigated rice (wet season) and corn (dry season) based on the 20 percent, 50 percent, and 80 percent probability levels of weekly rainfall, two planting schedules were proposed: an early planting requiring two periods of irrigation and a late planting requiring three periods of irrigation.

3-06 For the proposed water management scheme PTDF#2, the 50 percent probability level of weekly rainfall was assumed with the corresponding volumes of water deliveries computed based on continuous irrigation for rice and irrigation interval for 50% soil water depletion threshold for the corn crop. A *40%* overall water-use efficiency was assumed due to the unlined and erodible existing farm ditches. It is anticipated that efficiency can increase to 60% if the main farn ditches were lined. Irrigation water deliveries for both efficiencies are presented in the report (Annex III). This study shows the inappropriate terminal or farm level irrigation facilities existing at ARIP.

3-07 The computed design capacity for lateral canals serving diversified crops, in this case corn, showed that the minimum criteria of 2.25 lps per ha to be appropriate, providing large volume flows at intermittent periods necessary in irrigating the corn crops. Moreover, for sandy soils, lined main farm ditches are recommended in order to accommodate large volume flows at the turnout, preventing erosion, and conveyance losses.

3-08 Another component study conducted was the redesign of the farm level facilities at Lateral A-extra. Design and construction deficiencies were observed. The Parshall flume at the headgate of Lateral A-extra was found defective. Thus, a calibrated staff gage was installed to measure water flows entering the lateral. A decrease in the turnout service area ranging from 16 to 37 ha was recommended. This then increased the total number of turnouts from 8 to 11. Subsequently, an increase in the density of main and internal farm ditches was recommended from 515 m/ha to 712 m/ha. Moreover, the lateral canal was found to be in need of extension for another 800 m.

3-09 The location and lining of the main farm ditches are recommended to be constructed with the explicit participation of the farmers. Alternative materials, (clay, concrete hollow blocks) for lining will be evaluated for costs, conveyance efficiency, and stability, as part of the proposed second phase or extension activities at PTDF #2. The functional involvement of the farmers is expected to lead to the effective utilization of irrigation water and farm level facilities.

3-10 Horizontal and spatial subsurface movement of soil water (irrigation through seepage). At the Mani River Communal Irrigation System (MCIS) site, a study on the subsurface lateral movement of soil water or seepage water movement was conducted. This study was undertaken to determine the physical extent of how corn fields planted adjacent to rice paddies are actually irrigated through seepage. The results show that corn fields adjacent to rice paddies are irrigated through seepage. A significant increase in soil moisture up to a distance of 10 m was observed (Table 111.1 and Fig. 111.2). This can be attributed to the relatively coarser texture of the soil (in this case tupi, fine sandy loam) and the presence of the "sandstone" layer (see section para 3-03 and Fig. III.3).

3-11 Related to this study, a survey of 21 corn fields at: BARIS was conducted. In this survey, regular soil moisture sampling was undertaken. The purpose of this survey was to determine the seepage effects on corn adjacent to rice paddies at this system. However, there were only 10 samples that were finally assessed for comparison. Particularly for hybrid corn, irrigated samples were compared with the rainfed samples. Notwithstanding the limited samples, differences in yield, and soil moisture content were obtained (Table 111.2). This indicates the need for irrigation in the dry season in order to obtain optimum yield in this case at BARIS. Results of this preliminary study on the effects of irrigation through seepage needs further investigation to fully understand its implications in terms of approaches for irrigation and administrative feasibility (e.g. farmers' and NIA's explicit recognition of seepage effects as provided by the irrigation system).

3–12 This study implies an alternative irrigation method whereby rice and corn can be simultaneously irrigated. However, a more definitive study has to be conducted to fully assess the extent of this seepage soil water behavior. Moreover, there are other implications of this irrigation alternative for corn (e.g. willingness of farmers to pay irrigation fees) which need further study and discussion with both farmers and NIA.

3–13 Evaluation of farm level irrigation methods. The evaluation of farm level irrigation methods was conducted specifically to determine methods of improving current farmer practices to effectively irrigate diversified crops. For each of the study sites several methods were tried out in comparison to existing farmer practices in terms of actual water use, water–use efficiency, and additional labor used for improvement.

3–14 Existing corn irrigation practices at the Allah Valley Site indicated that basin–flushing–flooding was the norm. In particular, farmers at the BARIS irrigate corn with three days of continuous irrigation to cover 1 ha. The reasons for this time consuming practice are: a) low volume irrigation water flow deliveries to prevent farm ditch erosion and b) relatively flat or minimal field slope. This was observed during the 1984 dry season when farmers requested irrigation water for their corn crops.

3–15 Using 1/4 ha test plots, furrow and furrowed–basin irrigation methods were tried out at ARIP, PTDF#2, BARIS, and MCIS. Head or main farm ditches were constructed to allow an appropriate volume of water into these test plots. Results show that the furrow irrigation method has the least duration for irrigation (Table 111.3) compared to the basin method. A difference ranging from 0.8–2.1 hrs. was observed at the three study sites. The furrow method took from 2.4 to 4.4 hours to irrigate 1/4 ha while the basin method from 3.2–6.2 hrs.

3–16 Putting this information on a per hectare basis for similar soils (sandy clay loam) to irrigate 1 ha, the furrow method requires a maximum of 17 hrs compared with 24 hrs for the basin method. Limitations and requisites for this method indicate that for sandy soils, a maximum of 10 lps and for sand clay loam of 15 lps are allowable discharge for the furrow or the usual stream size. The corresponding furrow slopes ranged from 0.8 to 1%. Additional labor use for the furrow method was computed to be 144 Philippine pesos per ha. Land preparation costs for the furrow method were the same for regular basin or rainfed corn field preparation.

3–17 The results indicate the shorter duration and effective irrigation of corn compared to the existing practice but with additional labor costs.

3–18 The existing practice at Isabela, particularly at the CPPL IA and Sibester IA mean, for irrigation corn is the furrow method. To improve on the existing practice, double–row and triple row furrows were tested. An area of 0.97 ha and 0.4 ha were used for this study. The difference in size of test fields was due to the :Limitation in getting farmer cooperation. Nevertheless, the size difference did not significantly affect the results of the study.

3–19 The results of the study show that there were no significant differences in terms of yield, total water use, and labor use (Table 111.4). However, there was a significant difference noted in the CPPL IA site for the labor use. More man–days (MD) were used in irrigating double row furrows (3.47 MD) compared to triple row furrows (2 MD). Differences between sites were to some extent due to the differences in soil characteristics. These results indicate advantages both in labor requirements and in effective irrigation with no limitations in yield and water use.

3–20 The existing practice at the Cavite Site (SLBIP) particularly at the Bankud Irrigation System, is the basin flooding method. This existing practice for irrigating white beans was recently developed since the introduction of white bean production in the dry season of 1984. However, alternative irrigation practices were tested to improve on the existing practice.

3–21 The results showed (Table III.5) that while there were only minor differences in water use and yield among the three methods, there was a marked difference in labor use between furrow irrigation and basin flooding (4 to 4.5 MD compared to 0.5 MD). This was due to additional labor in directing and controlling water flows into the furrows which are not necessary in the basin method. Furthermore, certain specific irrigation practices indicate additional labor inputs for the furrow method. In the case of initial irrigation before planting, irrigation by basin flooding is applied prior to seeding in order to suppress weed growth. For the furrow method, however, first irrigation is applied after planting, which requires weeding afterwards.

3–22 Another difference between the two methods is the more frequent irrigation application for the furrow method. But this can be advantageous because during the last irrigation or at grain or bean formation, the basin method cannot be used since most pods are already touchfng the soil surface, and irrigation at this stage may result in rotting of the bean pods. This particular difference between methods becomes critical in times of serious soil moisture depletion.

3–23 Another advantage of the furrow is avoidance of water logging for which the basin method is susceptible. The white bean crop is very sensitive to water logging. Details of this sensitivity will be discussed in the next section on white bean crop-water use.

3–24 Similar to furrow Irrigation of corn, head ditches and end or drainage ditches within the field plots have to be constructed for effective irrigation and drainage of excess water.

3–25 System level study results. A study on the existing O&M procedures at the system level was conducted at a) Banga River Irrigation System (BARIS); b) Mani River Communal Irrigation System (MCIS); and c) Magat River Integrated Irrigation Systems (MARIIS), particularly at Lateral A. The study monitored actual irrigation deliveries and farming activities, implementation of schedules and maintenance procedures for the wet and dry seasons of 1985-86.

3–26 Banga River Irrigation System (BARIS). The system is basically operated to irrigate rice. In the wet season of 1985 only 1,630 ha were programmed for planting of lowland rice during the seasonal planning meeting, because of the low water supply caused by the siltation problem at the dam site. One sector was not scheduled for irrigation (sector IV). Due to insistent demand of the farmers in sector IV, they were later included starting in the month of August, making the total programmed area 1,930 ha. The flow measurements were installed by late August, already in the middle of the wet season which had started May 1, 1985. Sector 1 had already completed wet season activities during that time.

3–21 The water supply situation for the system and the three divisions are shown in Tables 111.6 to 111.9. The mean irrigation water supply in the system was 44 mm/wk and the mean supplies for Divisions A, B, and C were 90, 24, and 40 mm/wk respectively (Table III.6). This indicates inequity in water distribution with division A getting twice that of Division C and almost four times that of Division B. Division A is the upstream portion hence the opportunity exists to divert unscheduled water as it moves through the area. The laterals are closed when they are not scheduled since they are steel gated but the turnouts served directly by the main canal have no control facilities to prevent diversion. Division B is served by Lateral D and it has one supply point thus; their water supply is more controllable than the other divisions. The other divisions include many turnouts supplied by the main canal hence direct access to water is also possible. Division C is the tail end and return flows to the main canal are availed of by this division, hence they have higher irrigation water supply than Division B in the wet season.

3–28 In the dry season, Section IV lateral E and areas served by the main canal portions from the headgstes of lateral E and F were not scheduled to received irrigation water for rice. This schedule was agreed upon during the pre–season meeting between the IA and the NIA staff. This was the result of the yearly rotational schedule agreed upon by the farmers. The NIA staff suggested that these fanners plant corn instead. However, even with this agreed schedule, some farmers still persisted in planting rice in this section. The area planted to corn were as follows: Division A (mostly at laterals C & E) 40 ha., Division B (lateral D, sub–laterals D-1, D-2) 100 ha., and Division C (mostly downstreams of lateral F) 40 ha.

3-29 The dry season mean irrigation supply to the system was 74 mm/wk and for the Divisions A, B and C the values were 120, 77 and 63 mm/wk (Table III.8) respectively. This shows inequity in water distribution with Division A receiving much more water and Division B and Division C receiving less. It was observed that return flows are minimal in the dry season resulting in lower water supply in Division C. Though there were many weeks where the relative water supply was less than one, crop water stress did not occur due to the weekly water distribution rotation.

3-30 Area data gathered by NIA personnel is by division and cannot be delineated by sector. The large area served by the main canal makes it difficult to delineate by sector. However, water flows were measured up to the sector level. Using the water duty of 1.5 lps/ha (13 mm/day), these flows were converted into ares values and compared with the programmed area by sector. The programmed area per sector was the basis of the rotation schedule. This presents an alternative method of analyzing equity in water distribution (Table 111.10)

3-31 There is active farmer involvement in the seasonal irrigation planning for the BARIS system. System personnel are primarily concerned with irrigating 1500 ha of lowland rice in the wet season and about 1200 ha in the dry season. Irrigated corn is not included in the program. Farmers unscheduled for rice irrigation are encouraged to plant corn, and are allowed to avail of irrigation, when there is enough water after irrigating rice. Farmer sign promisory notes to pay their irrigation fees.

3-32 Corn is not programmed for irrigation due to uncertainty over the system's ability to supply irrigation for corn when there is insufficient rainfall; thus there is a probable loss of revenue for NIA in not charging irrigation fees for unprogrammed deliveries. The total available flow is programmed for irrigating lowland rice. Water availability for irrigating corn during drought is less since river diversion water may not be adequate for the rice programmed areas.

3-33 Another problem is the tendency of farmer groups who are not scheduled to plant rice to extend water delivery to their area. This is done mainly by enterprising farmers who try to plant two crops of irrigated rice in one season. This request is usually granted in the seasonal planning meetings to compensate for their not being scheduled in the next season. This creates late planting for corn, resulting in some farmers just letting their field lie idle till the next season when they are sure of being scheduled for lowland rice planting (refer to seasonal planning meetings in Annex 1).

3-34 Morever, it was observed that in areas scheduled for lowland rice irrigation farmers tend to plant rice only in low areas of their field and plant corn in the high areas. Since such areas are adjacent to each other, the corn areas are irrigated by seepage from the adjacent rice fields. Though these corn areas are apparently irrigated, the farmers cannot be billed for irrigation service because they are not directly served. The extent of irrigation by seepage of corn areas adjacent to irrigated lowland rice will be further studied in an extension of this study.

3-35 Since a large area of the corn planted in the system are adjacent to the rice areas and irrigated by seepage, there is a miscomprehension by farmers that corn areas do not normally need irrigation except in severe drought, as in the dry seasons of 1982 to 1984 when some farmers requested irrigation for corn areas.

3-36 With the rotation scheme, there seems to be little effort by the NIA to measure inflows into the canal systems. Their main objective is to see that water flows to scheduled sectors at a rate satisfactory to the farmers as determined by the feedback from IAs meetings. Under supply is easily monitored as farmers will complain immediately but oversupply is not reported unless farmers' fields are flooded. However, data gathered by the IIMI staff shows a real shortage of water during the dry season at the main diversion point and some inequitable distribution based on flow measurements within the irrigation network. These can be attributed to the frequent unauthorized diversion by farmers and also by the low and fluctuating water availability from the river as discussed previously.

3-37 Data reported to the NIA central office are condensed on monthly averages or total values which do not coincide with the weekly rotation of water. Areas planted are also assessed monthly. Water flow diversions to any sector are determined on weekly estimates of requirements though not recorded.

3-38 Most of the corn crop planted in late November relied on rainfall (see Fig. III.1), corn planted later was irrigated through seepage when planted adjacent to rice plots. In spite of the irrigable area planted to corn and the obvious benefit derived from irrigation, it is unlikely that the farmers will pay for irrigation unless a serious drought occurs.

3.39 Mani Communal Irrigation System. Out of the 732 ha service area of MCIS, only 354 ha was programmed for irrigation in the wet season of 1985. This was decided in the Irrigators' Association general assembly held before the start of the season. Section A has 132 ha programmed area while Lateral B had 108 ha (Fig 111.5). The same areas were programmed for the dry season beginning October 1985. When portions of the programmed area harvested their dry season crop early, the tail end of Lateral B was programmed for irrigation beginning January 1986 (Pig 111.6). Corn was not programmed to receive irrigation water. Corn was irrigated through seepage but not billed for irrigation fee payment. Direct irrigation of corn in this system was not practiced.

3.40 The observed flows were reduced to weekly water depths. For the wet season, the mean irrigation supply for the system was 67 mm/wk. Sector A had 69 and Lateral B had 66 mm/wk (Table III.11). In the dry season, the mean irrigation supply for the whole system was 63 mm/wk, in which case, section A had 51 and lateral B had 82 mm/wk (Table 111.12). This shows maldistribution of water with Lateral B getting more than Section A. Most areas served by section A got their water supply after the headgate of lateral B (Fig 111.5). Lateral B is upstream of Section A. The farm of the IA president is served by Lateral B. The ditchtender responsible for distributing water to the sectors is the son of the IA president. The poor distribution was not serious enough to cause moisture deficits in the rice crops planted. Nonetheless, these results showed that communal systems are not better managed than NIA irrigation systems.

3-41 The farmers appear to be satisfied with irrigating less rice area in the dry season. This is due to the seepage effects on corn planted adjacent to irrigated lowland rice. Hence, direct irrigation for corn is not practiced by farmers. Even during drought periods, only the corn fields planted away from the lowland rice fields exhibit moisture stress. These corn fields are far from the water sources, at higher elevations and lack on-farm water delivery facilities. Irrigating these areas will deprive water from areas already planted to lowland rice.

3-42 Irrigation of non-rice crops during the dry season is not a widely accepted practice at MCIS. This can be attributed to the availability of rainfall during the dry season and low income derived from non-rice crops relative to rice. As far as irrigation technology for corn is concerned, it has to be demonstrated to be profitable and any additional farm level facilities to irrigate corn will have to result in significant benefits before acceptance by farmers,

3-43 Magat River Integrated Irrigation System. Oversupply of water was observed in the Lateral A headgate of the Magat River Irrigation System for the period of the study. The actual irrigation (IR) supplied Is more than the irrigation diversion requirement (IDR) with means of 175 and 217 mm/wk respectively from October 1985 to April 1986 (Table 111.13 & Fig. 111.7). The irrigation diversion requirement was computed by multiplying the actual irrigated area with the water duty per ha. The mean values used were 59, 27, 29, and 30 mm/day for land soaking, land preparation, vegetative stage and reproductive stage respectively. This is high, as it is more than twice the values being used in other systems (13 mm/day).

3-44 Though the water duty was already high, the relative water supply average 1.5 units for entire period. This showed the abundance of water for the entire system. The availability of water for growing lowland rice is a deterrent to crop diversification in the area. Since the water duty for rice is high, it is desirable for efficient water use to introduce crop diversification. However, water is more than sufficient hence, it appeared to be not acceptable to the farmers. Unless profitability is assured, farmers will prefer growing rice than diversified crops: Rice yields in the area is high, according to farmers, averaging more than 5 tons/ha.

3-45 During the 1985 wet season (Fig. III.8), the farmers began planting during week 18. The maximum area planted occurred during week 35, 17 weeks later, at a time when the earliest plantings had already been harvested. Continuous rice cropping with three crops per year is practiced in parts of the system near the water source with abundant irrigation supplies. This creates problems in water distribution, and consequently inhibits crop diversification, particularly when farmers try to raise two crops of rice and a third crop of irrigated diversified crop in comparison to growing one crop of rice and one crop of irrigated diversified crop. Late planting encourages build up of pests and diseases which in turn discourage farmers from adopting crop diversiftcation.

3–46 A comparison of the nine–year mean rainfall with that of the actual rainfall for 1985–86 cropping season was made (Fig. 111.9). This indicates that 1985–86 was a relatively wet year as the actual rainfall was higher than the mean for previous years. The farmers that planted corn during the 1985-86 dry season depended mostly on rainfall. Timely planting of these crops in most years will not require irrigation due to sufficient rainfall.

3–47 Moreover, continuous irrigation as currently practiced further inhibits the planting of diversified crops. The MARIIS reservoir presently has sufficient water to irrigate rice on dual and diversified land classes which demands two or three times more than the designed irrigation water supply. However, in two or three years time, when full land development is completed and to irrigate 97,000 ha, problems will arise due to the fact that farmers in the system will heve become used to receiving large amounts of water on soils not suited for rice cultivation.

Agronomic Constraints

3–48 Testing of alternatives irrigated non–rice crops. A preliminary assessments of agronomic constraints for irrigated crop diversification was undertaken. Testing of alternative irrigated non–rice crops was conducted at the study sites to determine its actual field production, potential and adaptability in an irrigated environment.

3–49 At the Allah Valley Site, three crops were tested: a) early maturing improved open–pollirmted yelllow corn, b) mungbean, and c) peanut. These crops were planted at PTDF#2, lateral A–extra, BARIS and MCIS. Each crop was planted on a plot with an area of 1/4 ha to simulate actual farmers' field conditions. Data on yield and profitability indicate mixed results (Table 111.14). The corn yields obtained were not impressive. At the PTDF#2 site, problems on soil (low organic content) and pest and diseases were encountered. Late planting of corn at all sites brought about the pest and disease infestation. This also shows that relatively unresponsive characteristic of the open–pollinated corn to irrigation. The potential for irrigated corn was attained with hybrid corn. However, for the peanut crop, the highest yield was obtained at PTDF#2. Soil infertility did not affect the peanut crop much since legumes produce their own source of nitrogen. The proper timing of planting made the difference in yield for this crop. Peanut was planted later in the other two sites.

3–50 For the mungbean, no yteld was obtained at PTDF#2. This was caused by water logging which induced the infestation of nematodes and little leaf virus. This shows the sensitivity of mungbean to water logging. Excess irrigation was inadvertently applied by the farmer cooperator. For both the peanut and mungbean crop, problems in marketing were encountered.

3-51 Across all sites, the least yielding site was at BARIS (except the extreme production problem at PTDF#2 for corn and mungbean). This can be attributed to the late planting of all crops at this site. Problems in getting farmer cooperation were encountered at BARIS resulting in the delayed planting of the test crops. Thts shows the significance of proper timing in obtaining optimum yields.

3-52 At the Isabela site, comparative testing between Irrigated and rainfed peanut production was conducted. Two methods of planting for the irrigated treatment were used: a) raised bed and b) furrow methods. The sites were at San Mateo and Luna.

3-53 At San Mateo there were three irrigated field plots planted in January 1986, with soil texture ranging from clay loam to loamy sand. There was one rainfed field plot planted in November 1985 with sandy loam soil texture and only one irrigated field plot at Luna with silty clay loam soil planted in January 1986. There were however, two rainfed field plots planted in late 1985, one plot with sandy loam soil in early December and another plot with clay loam soil in mid December 1985. Based on the mean bean and pod yields and number of pods per plant sampled (Table III.15), the mean yields for the irrigated plots were higher than the rainfed field plots. Across sites the irrigated field plots had consistently higher yields than the rainfed field plots. These differences in yield can be attributed to soil moisture availability and timing of planting. For all sites, the rainfed field plots were planted earlier than the irrigated field plots. Results indicate that irrigated peanut'should be planted later (January) and preferably in sandy loam and clay loam soils to obtain optimum yield. The irrigated peanuts at San Mateo site showed higher yields than the irrigated field plots at Luna site. Finally, this study showed that there is a potential for growing peanuts in irrigated conditions (Table 111.15).

3-54 At the Cavite site, irrigated white-bean production was introduced. The NIA-MAF program provided incentives to encourage the production of white bean. White bean as a crop was selected for production due to the assured market provided by a pork and beans company and the corresponding profitability for farmers in the projected cost and return information (Table 111.16). Incentives in terms of credit on seeds, labor, fertilizer and pesticides, assured market, and land preparation assistance were provided. However, not all farmers who joined the program were successful in terms of profitability. Only 21 ha were planted out of a total of 100 ha as the production goal area.

3-55 The reluctance of farmers to join in the white-bean program can be attributed to unfamiliarity with the production technology despite the training provided. This was exacerbated by the unavailability of credit for farmers to join the program. Only a limited portion of the input costs were finally provided.

3-56 Despite the all out effort to promote white bean production, a few farmers suffered a net loss. Farmers who did not strictly followed the scheduled planting period, fertilizer and pesticide dosage obtained low yields. The white bean crop is sensitive to high temperature especially during the pod formation stage. The recommended planting period is from early November to mid December, so as to coincide the pod formation in the cold periods in January and February. Fertilizer amounts and timing are also critical to promote growth and enhance nodule formation. Bean fly and root rot are the two most common pest and diseases that infest the white bean. Proper control of these will aid in the optimum production of the white bean crop.

3–57 Nonetheless, the successful farmers were from the area in which the white bean production has been pilot tested the year before. The successful outcome of the pilot experience contributed to the farmers' adoption of white bean production for the second year in a row because of the continued support and incentives provided. The familiarity of the farmer with the proven technology showed the viability of irrigated crop diversification when external conditions are favorable.

3-58 Crop–water use of diversified crops. Specific component studies were also conducted to determine crop water use. The two crops studied were corn at the Isabela site and white bean at the Cavite site.

3-59 At the Isabela site a study on the root distribution of two varieties of corn, with three irrigation treatments and under three different textural soil types (fine, medium, coarse) was undertaken. The vertical root penetration for both varieties was observed to be more than 1 m at the San Mateo and Carulay sites where the soil types were coarse and medium respectively. In the Luna site (fine textural soil) root proliferation was hindered by presence of a hard pan. Depth of water table as also noted wtth the deepest water table at Carulay site (≥ 12 m), followed by Luna site (≥ 2 m) and the shallowest at San Mateo site (≥ 1.25 m). These physical parameters influenced root and water use uptake of the corn varieties planted.

3-60 The optimum water use in terms of irrigation treatments show that both irrigation at tasseling, silking and grain filling stages (11; Table 111.17) and at 50% moisture soil depletion (13; Table III.17) were effective in terms of grain yield. However, for shallow water table areas, irrigation at tasseling and grain filling stages is recommended €or optimum water use. The study also showed that the hybrid yellow corn (V2) variety out performed the open–pollinated white corn (V1) variety. Furthermore, the crop coefficients show that the maximum consumptive use of corn occurs at the flowering to grain formation stage (Table 111.18). This result indicates the critical stage where the corn crop will be most vulnerable to moisture stress.

3-61 At the Cavite site, a study on crop water use and tolerance to drought and water logging of the white bean crop was conducted. Accurate estimation was facilitated with the use of lysimeter tanks and pots.

3-62 The results showed that the mean water use of the white bean crop was 151 mm with a mean dry seed yield of 303 g/sq.m. (Table III.19). No significant differences were observed due to unexpected late rainfall at the UPLB experiment station. However, higher yields were obtained for irrigation applied at the reproductive stages. This is explained by the critical stage for moisture stress occuring at 31-60 DAS corresponding to the reproductive stage (Table III.20).

3-63, The water logging or flooding tolerance portion of the study was conducted in large pots. The results indicate that the white bean plant is sensitive to water logging particularly when it occurs at 30 DAS (Table III.21). Yield starts to diminish at two days of flooding. Maximum drainage occurs at four or more days of flooding especially when it occurs at 30 DAS. Observation showed that the white bean seeds were unusable and showed plants to exhibit mortality due to absence of aeration (available oxygen) for the roots.

3-64 This study also shows that the white-bean plant is sensitive at the vegetative stage (0-30 DAS). Although there were reductions in yield, water-logging at the later stage of plant growth (45 DAS) indicated higher yield than the plants flooded at earlier stages. Thus, this study showed that drought affects the reproductive stage while water logging affects the vegetative stage of the white bean crop.

Economic constraints

3-65 A preliminary assessment of the economic aspects of irrigated rice, non-rice and rainfed non-rice crop production was conducted. A component study was undertaken at the Allah Valley and Isabela sites.

3-66 At the Allah Valley site, particularly at the BARIS and MCIS study sites, profitability and labor use of dlfferent cropping patterns was assessed. Three cropping patterns were observed at BARIS: a) irrigated rice-rice b) irrigated rice-rice/corn and c) irrigated rice-corn. The results of the study showed that irrigated rice-rice had the highest profitability followed by the irrigated rice-rice/corn pattern (Table 111.22). Further analyzing the results obtained, a breakdown of the corn production data into irrigated and rainfed hybrid and open-pollinated corn was made. Comparing irrigated rice to irrigated hybrid corn, there were significant differences obtained (Table 111.23).

3-67 Except for fertilizer, seeds and returns to family labor, all other Ctems were found to be higher for the irrigated rice. This can be attributed to the higher fertilizer requirement of corn, higher costs of hybrid seeds, and lower family labor expended. The non-significant difference in returns to family resources can be attributed to the significantly higher production costs of irrigated rice. The study also showed that the higher costs of seeds and fertilizer for hybrid corn inhibits more farmer from growing corn. This is consistent with the farmers' responses on production problems encountered (high input cash costs) as indicated in the survey at BARIS.

3-68 Comparing the irrigated and rainfed hybrid yellow corn, there were differences obtained but they were not statistically significant (Table 111.24). Particularly in the yield component, the non-significant difference observed can be attributed to the occurrence of rainfall in the dry season which masked the effects of irrigation on the yield of hybrid corn (Fig. 111.3). The dry season of 1985-86 at Allah Valley was relatively wet compared to other years which did not clearly show the effects of irrigation on hybrid corn.

3-69 Another, factor is the higher costs of corn crop production relative to gross income or yield compared to irrigated rice production (Table 111.25). Despite lower total labor costs of irrigated upland crop production, the study also showed higher profitability of irrigated rice production, which in turn explained farmer preference for irrigated rice over corn in the dry season.

3-70 As discussed in the operations of BARIS, irrigation fee is not levied on corn. The NIA staff do not charge irrigation fee unless an explicit request for water to irrigate corn is provided. The seepage from adjacent rice fields and rainfall were sufficient to provide the necessary moisture to sustain corn production at BARIS.

3-71 At the MCIS site, a similar trend showed a higher profitability of irrigated rice compared to rainfed hybrid corn. Likewise, the labor use for corn was lower than for rice, as were total production costs (Table 111.26). Except for the fields tested for irrigated non-rice crops, all of the other non-rice fields were considered as rainfed. The abundant rainfall in this site during the dry season masked whatever irrigation effects, seepage, had on the non-rice fields (Fig. 111.4).

3-72 At the Isabela site, particularly at the SIBESTER IA, however, results showed that irrigated corn production was more profitable than rice (Table 111.27). This was due to the optimum yields obtained (approximately 5 tons/ha shelled corn) and high market price. However, only a few farmers in this area planted corn, and practically none at the CPPL IA area. This can be attributed to the low market price that prevailed at the end of the wet season of 1985 or at the start of the dry season 1985-86 compared to rice (Table 111.28). This low market price at the start of the dry season discouraged farmers to plant corn.

3-73 Moreover, production costs for irrigated corn were lower compared to rice in terms of labor, land rent, and other costs. No irrigation fee for the corn crop was charged by NIA as long as the previous fee for the rice crop was paid. Another unusual aspect of corn production in this area is the non-payment of land rent. The reason given by farmers is that landowners do not usually charge land rental for corn due to its insignificant income as long as the rice production income is shared.

3-74 The responsiveness of farmers to market price, particularly in the production of non-rice crops indicate the fragmented market structure existing at this particular site. Subtle forms of incentives such as the lack of charges in irrigation fees and land rental help to promote irrigated crop diversification. For this site, the main factors affecting crop diversification are the optimum productton and attractive market price.

Institutional Constraints

3-75 A preliminary assessment of the institutional constraints in the study sites was conducted. Problems associated with the formation and operation of IAs were assessed through component studies. Attempts were also made to look into the institutional arrangements required to promote irrigated crop diversification. Observations made in the system level studies provided additional information into the existing operational arragements these IAs have with the NIA field staff.

3-76 At the Allah Valley site, the IAs formally organized by NIA at ARIP and BARIS were surveyed in terms of their perceptions on their problems and operational activities (Table III.29). The farmer-managed or communal irrigation system at MCIS was also included in this survey. Thus, a comparative assessment can be obtained between the NIA and communal systems. There were generally good working relationships between the IA members and IA officers, NIA, and other agency staff (Table 111.30). The perceived problems affecting the IAs were attributed to: 1) members lack of interest in meetings, and 2) insufficient supply and unequal distribution of water (Table 111.31). The survey showed that farmers perception of responsibilities differ from what they actually render to the IA (Taoles 111.32 and 111.33). Responses in the perceived responsibilities did not match the responses in the activities rendered to the IA in terms of operation and maintenance activities.

3-11 This discrepancy in what is perceived and practiced was also apparent in the results of the system level management studies at BARIS and MCIS. Agreed upon schedules of irrigation water deliveries, in the case of BARIS between the NIA and the IA, were seldom adhered to, particularly by the upstream farmers. This was also observed in the MCIS. Blatant disregard of schedules resulted in the inequitable distribution of water, whereby the upstream farmers received more than their share of irrigation water, in these two systems. Seasonal decisions were ignored , making it harder to implement regular rotations and adhere to proposed cropping schedules. Deliberate suspension of irrigation schedules in response to rainfall and maintenance (e.g., dam desilting, repair of main canal washouts, etc.,), need to be better communicated to farmers to reduce the uncertainty over timing of irrigation deliveries. Better communication and implementation of policies appear to be the major constraints that are limiting the effective operation of the IAs in these two systems. These results also indicate that the communal system (MCIS) is not better off than the NIA system (BARIS) in terms of actual operational effectivity.

3-78 As far as the perceived benefits from the IA is concerned, indicative responses showed that sufficient water supply and increased income were the dominant reasons forwarded by the farmers (Table 111.34). This implies that the viability of the IA is dependent on the irrigation needs of the farmers. With regards to crop diversification, the responses of the farmers indicate ambivalence on their willingness to shift from rice to non-rice crops (Table 111.35). However, the popular choice of non-rice crops appear to be corn and mungbean. Particularly at BARIS and MCIS, the testing of alternative non-rice crops might have convinced farmers the profitability of mungbean production at these two sites.

3-19 At the Isabela site, two IAs were studied: SIBESTER IA and CPPL IA. Comparing the two IAs, the SISESTER IA was more active than the CPPL IA in terms of participation in meetings and group work in maintaining or cleaning of canals. The study also showed that the CPPL IA is beset with problems caused mainly by ineffective Leadership. Other causes of problems were dependence on NIA's continued support and guidance, and structural defects in the irrigation facilities. As shown in the system level study results, farmers ignore schedules of water delivery. Better communication between the farmers and NIA in terms of O&M will reduce the uncertainty on irrigation needs, despite the abundance of water supplied into these two IA sites.

3-80 Crop diversification at this site was unanimously perceived in both IAs as feasible if the market price of corn and other non-rice crops will be attractive and stable enough to warrant a shift from rice. The abundance of irrigation water for rice exacerbates the economic constraint as reflected in the unfavorable market price of corn.

3-81 With regard to farmer decision making behavior regarding irrigated diversified cropping, the conditions for successful adoption appear to be hiernrchichal in nature. The physical and biological conditions (limited water supply, suitable soils, familiarity with non-rice crop technology) must be met together with the input and output requisites (credit, family labor, market availability) for production. The profitability factor then becomes the dominant consideration fox farmers to adopt or practice irrigated crop diversification.

IV. ASSESSMENT AND TMPLICATICINS

Irrigation Factors

4-01 Four irrigation constraints to crop diversification are identified: dry season rainfall patterns, availability of irrigation water for rice, limitations in Irrigation management, and inappropriate on-farm irrigation and drainage facilities.

4-02 At Allah Valley and to some extent at the Isabela site there is frequently sufficient rain to permit upland crop production without irrigation water. Providing irrigation under such conditions encourages rice cultivation because of the danger of water logging when rainfall occurs after irrigation. In areas where crop diversification has been successful, climatic factors such as little or no dry season rainfall (e.g., at Pangasinan, Nueva Ecija and Ilocos Norte) is an important reason for the success. Crop diversification under irrigation is much less successful when dry season rainfall is plentiful.

4-03 However, based on the rainfall simulation study undertaken at the Allah Valley site, there are years in which rainfall is insufficient to sustain optimum dry season corn crop production. Further trials of irrigated corn are necessary to determine optimum production and profitability levels.

4-04 At the Allah Valley and Isnbela sites, crop diversification is to a large extent discouraged by the continuous supply of irrigation water. Irrigation is seen as synonymous with rice production. If water is delivered in sufficient quantities to grow rice, farmers do not grow irrigated upland crops. This is particularly true at the Allah Valley site, where lateral seepage affects plots of corn .adjacent to rice fields. In Isabela, water is currently delivered at two to three times the designed rates, encouraging farmers to grow rice rather than other crops. It is difficult to achieve crop diversification under such conditions.

4-05 Irrigation management techniques have not yet been developed in any of the sites that allow precise delivery of water. Results from all sites show that irrigation is continuous in the main system. Inadequate control and lack of measuring devices make it extremely difficult to deliver large volumes of water at intermittent periods, the optimal system for diversified crops.

4-06 Design capacities of lateral canals should be increased in order to accommodate large and intermittent volumes of flow. However, the results of the study at PTDF#2 and the surveys of existing canal capacities show that these flows can be accommodated provided appropriate control and scheduling are undertaken. Based on the computations made at PTDF#2, where sandy soils are prevalent, a design criterion of 2.25 lps/ha will have to be considered. The experience in Taiwan demonntrates clearly that strict control over water is the foremost factor in developing farmer confidence in their water supplies for crop diversification (see Interim Report, Taiwan Study Tour Report). It is suggested that improvements are made in scheduling water deliveries for diversified crops, and attention be paid to the need for increased control structures and measuring devices to allow greater control over water deliveries.

4-07 On-farm irrigation facilities require modifications to provide the proper water conditions for diversified crops. Continuous flows of irrigation water result in water logging on heavier soils and require long periods of management on fields. To overcome these constraints it is recommended that irrigation deliveries be rescheduled to provide large volumes to be delivered for shorter periods to speed up irrigation from three days to one day per hectare. Turnout capacities should be increased by as much as two times (3.0 lps/ha), in order to achieve large volume flows as indicated in the results of the study at PTDF#2. To attain this, it will require additional investigations in determining optimal ditch density of farm irrigation and drainage citches and development of less erodible farm channels. It is recommended that farmers adopt furrow irrigation rather than basin flooding to speed up the time of irrigation and provide more uniform water applications on their farms.

Agronomic Factors

4-08 There is widespread unfamiliarity with the non-rice crop production under irrigated conditions. In Allah Valley and Isabela most non-rice crops are grown under rainfed conditions, or through the utilization of seepage water from adjacent rice fields. Where dry season rainfall is adequate in most seasons, there is clearly unwillingness to risk waterlogging of non-rice crops using irrigation water. The result is that yields do not reach their full potential and production is much lower than rice. In the drier areas, there is a wider acceptance of crop diversification, and improved agronomic practices are evident. It is recommended that in areas where rainfall is more widespread in the dry season, a greater effort be made to demonstrate the benefits of irrigation of diversified crops, particularly in the timing of irrigations in relation to the growth stages of the plant, and the need to determine when irrigation is required to avoid moisture stress. This must be supported by irrigation management more responsive to crop water requirements.

4-09 Timing of cultivation of non-rice crops is particularly important when there are factors such a8 temperature, incidence of pests and diseases, and risk of waterlogging through heavy rainfall. Cropping patterns will have to be evaluated in light of these environmental factors that impact diversified crops more than rice. This in turn requires greater attention to cropping schedules and a clear identification of seasons in which non-rice crops should be promoted.

4-10 The results from Cavite demonstrate that agronomic constraints to crop diversification can be overcome with proper extension efforts, and assistance in procuring appropriate crop care technology. In other sites it is recommended that more emphasis be placed'on overcoming the agronomic constraints so that production levels can be raised to levels attractive enough to justify the extra input costs in fertilizer, pesticides, crop care, and irrigation.

Economic Factors

4-11 The main economic constraints identified in this study are the unfavorable prices for most crops in comparison to rice, and the higher costs of crop care for diversified cropping. Even if the irrigation conetraints to diversification are alleviated, there is no guarantee that the economic conditions will favor widespread adoption of diversified cropping.

4-12 Where market prices are assured and have comparable stability to rice prices, there is clear evidence that crop diversification can be achieved. The results at the Cavite site show that most farmers who have grown white beans in one season will continue to grow them the following year. At the Isabela site, the dominant reason cited by fanners that constrains them from diversifying in the dry season is the unstable farm gate price of corn. Similarly, in other sites where marketing arrangements have been unfavorable, diversification has been retarded. It is recommended that an investigation on the market structure and post-harvest facilities be conducted in order that incentives for stable pricing of non-rice crops can be provided. Other indirect incentives such as reduction of irrigation fees for non-rice crops should be further studied.

4-13 In all sites, the cash input costs (before harvest) for non-rice crops are higher than for rice production, although the labor requirements are less. At present this is due to low production levels, and removal of the agronomic constraints would raise the profitability of diversified cropping. Support for input costs, as in the Cavite case can be made in removing some of the risks foe farmers and encouraging them to shift away from rice production in the dry season. However, this has been specifically undertaken to generate guaranteed supplies for the bean processing industry. Similar total package support, including input and output considerations, are recommended in other areas in conjunction with improved irrigation and agronomic measures.

Institutional Factors

4-14 There is a clear need to improve the communication between the IAs and NIA. Irrigation schedules need to be better communicated and implemented to reduce the uncertainty over timing of water deliveries. This assessment applies to both NIA systems and communal system as shown by the results of the study. In all of the sites, where continuous irrigation was practiced for rice, ways to irlprove implementation of water delivery schedules are needed, more so if diversified cropping is to be adopted in these systems.

4-15 The intermittent and large volume of flows attendant to diversified cropping irrigation will requlre better communication between farmers and syatem operators to overcome the uncertainty over water delivery Schedules. Ways to improve the communication and implementation of water delivery schedules have to be investigated *to* fully utilize the capabilities of the **IAs.** The preliminary study indicated that the viability of the **IAs** depends on the benefits derived by **the** farmer members and the foremost benefit identified is the sufficiency of irrigation water supply for his crop. Studies to improve the joint [management of IAs and NIA will lead to better communication and reduce farmers' uncertainty over water delivery schedules.

V. IRRIGATION FOR CROP DIVERSIFICATION (SECOND PHASE)

Background

5-01 Ambivalence towards the prospects for efficient and profitable production of irrigated crops other than rice in the Philippines remains. Technical (in respect of both agricultural and irrigation technologies), economic, and institutional factors affecting the performance of irrigated non-rice crops are not yet adequately understood to permit definitive assessment of future cropping trends. The Phase I Study utilized field studies to examine the more important of these issues in depth.

5-02 The results and implications of the study on irrigation management for crop diversification show that among the identified constraints, the irrigation and economic factors are the items that need further investigation. Irrigation management practices that will lead to profitable cultivation of non-rice crops in the dry season necessitates further assessment to arrive at definitive results and guidelines. These guidelines will have to evolve out of the examination of existing and testing of promising irrigation practices as an alternative in improving the. effectiveness of irrigation systems particularly in the dry season.

Rationale for a Phase II Study

5-03 The results of the initial study showed that there are important technical and socio-economic aspects to irrigation management for diversified cropping which are not understood, and which exert a profound effect on the profitability of cultivation and the return on investment in irrigation. Several constraints to successful diversified cropping in irrigated areas were identified, together with suggested ways to mitigate those constraints.

5-04 These results must be considered preliminary, however, due to the limited study period (22 months and only one dry season) during which the study was conducted. This period was understood at the outset as sufficient only to open up the issues for further study with sharper focus, and to establish administrative and substantive relationships at several field sites which could lead to conclusive results over a longer period. To capitalize on the investment in the phase-one project, a more detailed study is needed.

5-05 The Study Advisory Committee (SAC), comprising representatives of three Philippine Government agencies (National Irrigation Administration [NIA], Ministry of Agriculture [MAF], and the Philippine Council of Agriculture and Resources Research and Development [PCARRD]), the Bank and IIMI, strongly endorsed the extension or second phase of the study at its 13 August 1986 meeting. To ensure that the study contribute to the larger goals of agricultural productivity in irrigated areas of the Philippines, the Committee recommended that priarity be given to the extension of studies on 1) managing the main and distribution network of irrigation systems, 2) on-farm irrigation methods and facilities, 3) agronomic practices, and 4) economic and institutional aspects of irrigated crop diversification.

Concepts and Objectives for the Phase II Study

5-06 The Phase II study is proposed as an extension of IIMI's initial work on irrigation management for crop diversification in the Philippines (TA 654 PHI).

5-07 Concepts. It is not the purpose of the proposed study to promote a major shift in cropping pattern from irrigated rice to other crops. Such shifts, when they occur, are responses to a range of factors such as relative prices, national policies, and technological innovations, and not to field studies of limited scope.

5-08 It is clear, however, that many Philippine farmers are producing non-rice crops in the command of irrigation systems and with highly variable results. Reasons for successful or unsuccessful cultivation are not well understood either by irrigation or agriculture officers, nor sometimes by the farmers themselves. Practical guidelines for farmers, extension agents and irrigation staff to grow non-rice crops more successfully through irrigation simply do not exist. It is the broad purpose of this proposed study to generate some of the more important of these guidelines.

5-09 Virtually all public irrigation systems in the Philippines were designed, built, and operated for lowland rice in the wet season. The great majority of the irrigated area is supplied from run-of-the-river barrages on streams and rivers. These systems provide quite stable sources of water during the wet season, but essentially none of them has enough water to irrigate rice throughout the lull command in the dry season. Typically, the limited water available in the dry season is used to irrigate rice on a small part of the command of each system.

5-10 During the past 20 years, technological change has resulted in a gradual increase in the value of irrigation in the dry season. The main reason for this shift is the adoption of modern rice varieties whose yield potential is much higher in the dry season than in the wet. The economic viability of farming and of investments in irrigation systems is increasingly dependent upon dry-season cultivation.

5-11 Competition for the limited supply of dry-season water has increased greatly as a result. It takes almost twice as much water per ha to grow rice than upland crops in the farm level. Headend farmers take whatever measures they can to appropriate more water to their fields, particularly if rice is grow in the dry season. This system of irrigation is characterized by disorder, inefficiency, and iaequity.

5-12 Other sources of inequity stem from variable soil conditions. Irrigation commands comprise areas ranging from coarse river-levy soils to heavy clay backswamps, often within a few hundred meters. The coarser soils are usually located near the source of water where dry-season farming is concentrated. The result is that farmers attempt to grow rice on the areas well suited for that crop. These areas require much larger rates of water supply than the system is designed to carry because of the high seepage losses from such light soils. It has been estimated that some irrigation systems supply over 60% of their total water to only 15% of their commands for this reason.

5-13 Farmers have begun trying to grow crops other than rice on such soils in the dry season. Where successful, they have made possible a large increase in the area irrigated because those crops use less water for crop growth and lose less water through seepage than does rice. Experience, however, has been generally disappointing. Conflicts between rice and non-rice farmers have resulted due to the different irrigation demands of the crops. Markets do not exist to absorb the product of most new crops. Farmers experience difficulty converting their lands from a puddled soil condition to upland for the dry season, and back again for the wet season. In short, although irrigation of diversified crops requires less water than that for rice, it requires substantially greater management control over the water.

5-14 From the above, overall irrigation system efficiency and productivity will increase through a judicious combination of rice and upland crops during the dry season. The study is designed to establish appropriate irrigation policies and practices to support the combined production of both types of crops.

5-15 Objectives. The primary objective of this Phase II is to determine those irrigation practices most likely to enhance the cultivation of selected non-rice crops in limited parts of irrigation systems during the dry season, and to field-test the most promising of those practices in selected commands.

5-16 Associated objective; are to:

a) Develop a criteria or methodology for identifying those parts of irrigated commands wlth comparative advantage for selected diversified crops;

b) Compare the profitability of selected diversified crops under irrigated and rainfed conditions, and to compare their irrigated performance with that of irrigated rice;

c) Determine the primary factors and their interaction which condition how farmers prepare Land for irrigated rice in the wet season and for one or more diversified crops in the dry season,

d) Develop on-farm irrigation methods for at least one upland crop;

e) Design and field-tea: operating procedures for publicly-managed portions of irrigation systems; and

f) Recommend those policies likely to support more profitable farming practices and more profitable investment in irrigation development as related to diversified crops and arrive at guidelines for irrigation management practices.

5-17 It is important to clarify what the study does not propose to do. It is not proposed to undertake varietal or agronomic trials of crops, nor to compare different diversified crops with the objective of finding optimum crops. It is not proposed to undertake macro-economic analyses of market prospects for any crops. The study is not designed to carry out research on irrigation structures at either the system or on-farm levels. It is the objective of Phase II to develop and field-test practices which will make diversified cropping with irrigation more profitable, but it is Government's prerogative if it wishes, not IIMI's objective, to press rice-growing farmers to adopt them.

Selection of Field Sites

5-18 The studies will be conducted at seven irrigation systems on Mindanao and Luzon Islands. All three systems selected in Mindanao were included in the Phase I Study. Some Phase I work was carried out in the Luzon systems too, but the Phase II proposal envisages an extension of the work to include both Mindanao and Luzon with roughly equal weight.

5-19 On Mindanao Island the following systems have been selected:

1) Allah River Irrigation Project (ARIP).

2) Banga River Irrigation System (BARIS).

3) Mani River Communal Irrigation System (MCIS).

On Luzon Island:

1) Bonga Pump # 2 (Bonga River Pump Irrigation System Number 2, BP#2) or an appropriate pump system in Bulacan or other provinces.

2) Laoag-Vintar River Irrigation System (LVRIS).

3) Upper Talavers River Irrigation System (Upper TRIS), and

4) Tarlac-San Miguel-O'Donnel River Irrigation System (TASMORIS).

5-20 The sites on the Mindanao Island were included in the Phase I study and already have data and information that will be of significant value in carrying out the objectives set for Phase II. As a continuation of the Phase I study, this Phase II will greatly benefit from the information already gathered from these sites in arriving at definitive results in assessing the profitability of irrigated diversified cropping both in new and existing irrigation systems where no previous irrigated diversified cropping is widely practiced in the dry season. Furthermore, the sites selected approximate conditions (climate, soils, topography, and watershed characteristics) representative of irrigation systems located in the island of Mindanao.

5-21 The sites on Luzon Island were selected in accordance with the desirability of having irrigation systems where diversified cropping is already being practiced in the dry season. The first three sites above fulfilled the criteria of having dry season diversified cropping whereby irrigation management practices can be documented and assessed for improvement and dissemination. Moreover, the LVRIS in Ilocos Norte and Upper TRIS in Nueva Ecija, were also included in the Phase I study as sites where successful irrigated diversified cropping were preliminarily surveyed. These two sites are run-of-the-river systems that are typical of most systems in the Philippines in which dry season water supply is limited and soils are suitable for diversified cropping.

5-22 The BP#2 in Ilocos Ncrte was selected as another site to represent an irrigation system with a different source of water supply, where the incentive to optimize water use through diversified cropping is paramount in reducing the cost of irrigation water. Finally, the TASMORIS in Tarlac was included to assess the adaptability of irrigated diversified cropping in the dry season in conjunction with NIA's Dry Season Irrigation Management Program located in this system. This is a run-of-the-river system where water is limited in the dry season end soils are suitable for diversified cropping.

5-23 These systems provide a range of climatic and soil conditions representative of the three most important irrigated regions of the Philippines. Their selection was based on many factors including the availability of NIA field and counterpart staff who will assist in carrying out the studies.

Terms of Reference

5-24 The Study will be carried out according to these terms of reference, which closely follow the stated objectives above. The Study will:

1) Determine for one system in Mindanao and one in Luzon those limited areas for which selected diversified crops are particularly well suited, taking into account the nature of the soils, topography, distribution system, rainfall, and other relevant factors. From thie information a more generalized methodology for identifying such areas will be developed and field tested on one or more additional systems.

2) Determine for each of the seven sample systems the dry-season yield levels, costs of production, gross returns, and net returns, taking into account actual and imputed labor costs, for

   a) one or more irrigated diversified crops,

   b) the same crop grown under nearby rainfed conditions, and

c) irrigated rice. Lifferential effects, if any, on the performance of wet-season rice will be imputed. Costs will take due consideration of the cost and availability of credit, and prices received will take into consideration marketability of the crop(s). From this information a comparison will be made to place the economics of irrigated diversified cropping within the context of alternatives available to the farmer. For two of the systems, the results will be further analyzed according to different assumptions or data on the management of irrigation supplies.

3) Determine for one Luzon system the primary factors and their interaction which condition how farmers prepare their land for a diversified crop following wet-season rice, and how they manage their land to prepare for wet season rice again, giving special attention to labor and power requirements for tillage, timeliness, moisture regimes, provision for field channels, and other relevant factors.

4) [A]. Determine and field-test appropriate cost-effective irrigation methods at both the field level and system level in one system in Mindanao and one in Luzon, to find practical values for recommended (i) intervals between, (ii) duration, and (iii) stream size of irrigations. The field-level studies will give special attention to (i) extent and management of seepage from adjacent ricefields as a source of water for diversified crops, (ii) basin flooding vs. different forms of furrow irrigation, (iii) density and placement of on-farm channels and structures, and (iv) means to communicate and relate between the on-farm and main-system practices. The farm level sites will be selected within the systems representatives of head, middle, and tail locations. The systems-level studies will give special attention to cost-effective and manageable means of providing irrigation cn an intermittent basis, keeping in mind the need to irrigate both rice and diversified crops from the same system. These studies will include the determination of critical points within the system for monitoring and control of flows, irrigation intervals and schedule, canal capacities, manpower capabilities for operating the system and improvements in the physical facilities to allow the implementation of irrigation management practices for both rice and non-rice crops in the dry season.

4) [B] Document and analyze current methods in use during the dry season for irrigating diversified crops in the five other sample systems, and analyze them for more general applicability.

5) Recommend appropriate irrigation management practices from the above, and propose a set of guidelines in the form of "Philippine Recommends for Irrigation Management for Diversified Cropping." This series of guidelines will be more concrete in their recommendations for actual field practices, and will be the

subject of the workshop and various training activities carried out in the study. This set of guidelines will also have significance for projects in the country other than those taken up in the study and will have some value outside the Philippines.2

Implementation Arrangements

5-25 The executing Agency for this Technical Assistance Phase II Study will be the International Irrigation Management Institute (IIMI). IIMI will carry out the studies in close collaboration with the National Irrigation Administration (NU) which is the lead government agency, together with the Philippine Council for Agriculture and Resources Research and Development (PCARRD) and the Ministry of Agriculture and Food (MAF).

5-26 N U will be the lead agency for the two irrigation projects and other irrigation systems in wtich the study sites will be located. NIA will also be the executing agency for agricultural development in ARIP, while for the others the NIA irrigation systems offices will be the cooperating agencies. MAF will also be a cooperating agency in respect of trials with appropriate non-rice crops. Studies involving crop production in all of the selected study sites will be carried out in close coordination with the lead research agencies of the PCARRD consortium. These agencies are the University of Southern Mindanao in Kabacan for ARIP, BARIS, and MCIS; the University of the Philippines in Los Banos; the different state colleges and universities under the Central Luzon Agricultural Research Center in Munoz for the Upper TRIS and TASMORIS; and the Mariano Marcos State University in Batac for the Laoag-Vintar RIS and Bonga Pump #2. It is intended that the component studies be conducted in association with IIMI. The research studies in the Phase II Study will be included in the annual review and evaluation being conducted by PCARRD as part of its regular coordination of agricultural research projects.

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2 IIMI recognizes the importance of appropriate institutional relationships to support the irrigation management practices which will be field tested in this study. IIMI cannot address institutional issues adequately within the budgetary limitations imposed by the project. The source of support have been identified which will enable IIMI to apply staff resources, both within the Philippines and from headquarters to do an effective comprehensive study of institutional relationships within the appropriate framework of this study. The institutional study will document the structure and decision making processes of both the NIA and the Irrigators Association (IA) as they relate to dry season water distribution; document patterns of cooperation among farmers within the LA and the NIA. Other issues to be documented will include: (a) the structure and payment of irrigation service fee charges, (b) adherence to cropping schedules, (c) staff training, and (d) such other information as is deemed relevant by the IIMI Project Coordinator.

5-27 The IIMI Coordinator for the Phase I Study or his replacement will direct and coordinate the Phase II Study Implementation. The IIMI local (Philippine) staff will continue to carry out on-site studies and data collection for each of the selected study sites. These include one Research Associate and four Research Assistants. Consultants and research assistants will be hired as needed to supplement this manpower. IIMI will provide a consulting Agricultural Economist at the international level to coordinate and provide guidance to the economic studies. Research staff from the cooperating agencies or universities belonging to the PCARRD network of research consortia will be engaged as local consultants. To facilitate implementation, NIA will continue to provide site office accommodation and assistance in data collection through its field personnel.

5-28 The Phase II Proposal is planned for a 29-month period commencing January 1987. However, in order to cover three dry seasons within this period, data collection will begin in November 1986, which is the beginning of the dry season in most of the study sites. .

Activities

5-29 Some Phase II Activities will begin in November 1986, before the formal opening of the Phase I1 study, because the dry-season crop begins during that month at many of the study sites.

5-30 Assignment of manpower to the five Study Activities described in the Terns of reference are proposed on the following page, subject to possible modification.

PHASE II PROPOSED ACTIVITIES

Study Activity	Sites	Methodology	Manpower (man-months) IIMI Proj Coord	IIMI Local Staff	IIMI HQ Staff	Local Cons. Staff
1. Development of methodology to identify areas.	1. ARIP 2. TASMORIS or BPIS	- Conceptual work; - Field measures; - Photogrammetry.	4	36	1.5	2
2. Economics of diversified and rice crops.	All Sites	- Interviews; - Record-keeping; - Limited crop-cuts.	2	15	2.0	8
3. Land management practices.	Upper TRIS or BPIS	- Monitoring; - Field meaaures.	4	20	0.5	6
4. Irrigation system practices.	All sites	- Flow measurement; - Field monitoring; - Historical records; - Field test (select).	9	144	2.5	6
5. Institutional arrangements 6 recommendations.	All sites	- Interviews	5	17	1.5	6
Totals:			24	232	8.0	28

5-31 The Project Coordinator will spend a total of 24 months on the Study, all but five of them in the Philippines. Two months will be allocated to leave and three to Project-related work in Sri Lanka. The distribution of these months against the different Activities is approximate.

5-32 IIMI Headquarters or Headquarters-contracted Staff include all internationally-recruited staff assigned to Project work. They will include engineers, economists, agricultural scientists, management staff and social scientists totalling eight months of time.

5-33 Local consultants associated with the Study will be as follows:

1. Univ. of Southern Mindanao (USM), for all Activities at ARIP, BARIS, and MCIS;

2. Central Lueon State Univ. (CLSU), for all Activities at Upper TRIS;

3. Univ. of Phils. at Los Banos (UPLB) for all Activities where the availablo expertise will be appropriate;

4. Mariano Marcos State Univ. (MMSU) for all Activities at LVRIS and BP#2; and

5. Pampanga Agricultural College (PAC) for all Activities at TASMORIS.

5-34 PCARRD staff will collaborate with the Study at Sites and in Activities for which PCARRD has special interest, particularly in the publication of the Philippine Recommends for Irrigation Management for Crop Diversification. PCARRD and IIMI have signed a Memorandum of Agreement to facilitate this collaboration.

Reports

5-35 A first or initial progress review report will be presented by IIMI after 8 months, a second progress review report after 14 months, an interim report after 18 months, a workshop report after 22 months, a draft final report after 28 months, and a final report on completion of the 29-month period,

5-36 The first or initial progress review report will consist of the completed activities for the first dry season and proposed studies and plans for the next 12-month period,

5-37 The second progress review report will consists primarily of the completed activities and on-site evaluation report (February 1988) of the review mission from the Bank and other members of the SAC.

5-38 The interim report will include the accomplishments and adjustments (if any) of the Study after two dry seasons (June 1988). It will also provide the materials for the workshop scheduled for September 1988. A draft of the set of guidelines in outline form will also be included at this stage of reporting.

5-39 The workshop report will consolidate the results of the two dry seasons and assessment of data and information from studies conducted by other agencies relevant to irrigated crop diversification in the Philippines. The report is intended to be used in formulating recommendations and policy-oriented suggestions. It will also provide an opportunity for adjustments, if necessary, before carrying out the field-test activities during the last dry season. A more detailed set of guidelines will accompany the report at this stage.

5-40 The draft final report: will consolidate all the accomplishments of the Study and document the results of the field tests. A completed draft of the set of guidelines will also be submitted at this stage.

Cost Estimate

5-41 The cost of the proposed Phase II Study tschnicnl aarirtance is estimated at $415,000 of which $350,000 will be financed by the Bank and $50,000 by IIMI and $15,000 notional coats by NIA. These will be no counterpart funding required from the Government; however, ae noted above, NIA staff already employed at the project sites and in related rsrearch activities will assist and cooperate in the study and NIA will provide site office accommodations. These activities will not involve additional or incremental expenditures by the government.

5-42 Since there will be a two-month (November and December 1986) advance on start-up time in 1986 for the first dry season activities, IIMI will provide interim support during this period contingent upon the Phase II Proposal being funded beginning January 1987.

Table I.1 Water use, critical growth stage, crop duration and moisture sensitivity characteristics of selected non-rice crops in the Philippines (PCARR, 1982).

Crops	Depth/year or /season (mm)	Average growing (days)	Critical period	Remarks
Corn	600	90–120	Tasseling to grain formation	Sensitive to very shallow water table
Bean	300–500	60–90	Flowering and pod development	Vegetative period is sensitive to water logging
Cotton	700–1300	150–180	Flowering period	Over supply of water retards fruiting and branching and delays maturity. It should not be allowed under water–logged conditions at any stage of the growth for more than 4 days.
Garlic.	360–400	90–120	----	This requires moderately wet soil
Onion	350–550	90–100	Period of root bulb formation	------
Peanut	580	140–160	Peak of flowering and early fruiting	------

Table I.2 Perceptions on sufficiency of irrigation water for rice and dry season cropping at SFRIS, Agno RIS, Upper TRIS, and LVRIS dry season 1985-86.

	SFRIS (Tobacco)	Agno RIS (Cotton)	Upper TRIS (Onion)	LVRIS (Garlic)
Sufficient water for rice				
1) Yes	13 (33%)	30 (75%)	16 (40%)	15 (23%)
Actually planted rice				
Yes	5 (39%)	16 (53%)	8 (50%)	10 (67%)
NO	8 (61%)	14 (47%)	8 (50%)	5 (33%)
2) No	27 (67%)	10 (25%)	24 (60%)	51 (77%)
Expected to plant rice if sufficient water is available				
Yes	16 (59%)	0 (0%)	10 (42%)	18 (36%)
NO	11 (41%)	10 (100%)	14 (58%)	32 (64%)

Table I.3 Comparative labor use, input cash cost, profitability, and net returns of tobacco, cotton, onion, and garlic to rice at San Fabian RIS, Agno RIS, Upper TRIS, and LVRIS, dry season 1985-86.

	Rice	Tob/R	C/R	O/R	G/R
CASH COSTS					
Hired Labor	2342	0.60	0.78	2.56	1.39
Seeds	435	0.00	0.00	9.84	29.17
Fertilizer	1243	1.82	1.51	.00	1.25
Chemicals	290	5.60	8.57	3.72	1.78
Total Cash costs (including other cash cost)	7507	1.22	1.39	3.22	1.94
NON-CASH COSTS (Family & Exchange Labor & Mgt.)	1811	4.80	2.58	7.08	11.78
RETURNS	11035	1.86	1.89	3.70	2.19
Net return above cash cost	3528	3.48	2.59	4.77	2.69
Net farm income	1617	(-)	2.59	3.75	(-)

Tob = Tobacco C = Cotton R = Rice
O = Onion G = Garlic

(-) negative net farm income
Rice = mean values in Philippine pesos per hectare for all sites

Table I.4 Marketing aspects of tobacco, cotton, onion and garlic at SFRIS, Agno RIS, Upper TRIS and LVRIS respectively, dry season, 1985-86.

	Tobacco	Cotton	Onion	Garlic
1. Special arrangement w/ buyer				
Yes	36 (90%)	40 (100%)	13 (33%)	2 (3%)
NO	4 (10%)	0	27 (67%)	58 (97%)
2. Buyer providing seeds				
Yes	1 (3%)	40 (100%)	6 (15%)	0
NO	39 (97%)	0	34 (85%)	60 (100%)
3. Buyer lending money				
Yes	23 (58%)	40 100%)	2 (5%)	0
NO	17 (42%)	0	38 (95%)	60 (100%)
4. Buyer providing fertilizer				
Yes	25 (63%)	40 (100%)	2 (5%)	0
NO	15 (37%)	0	38 (95%)	60 (100%)
5. Buyer providing chemicals				
Yes	24 (60%)	40 (100%)	1 (3%)	0
NO	16 (40%)	0	39 (97%)	60 (100%)
6. Price agreed upon before planting				
Yes	5 (13%)	40 (100%)	10 (25%)	1 (2%)
NO	35 (87%)	0	30 (75%)	59 (98%)
7. Point of sale				
On farm	3 (8%)		19 (48%)	2 (3%)
Within barrio	34 (84%)	36 (90%)	17 (42%)	13 (22%)
Outside barrio, w/in municipality	3 (8%)	4 (10%)	4 (10%)	5 (8%)
Outside municipality, w/in province	0	0	0	0
8. Produce transported				
Yes	8 (20%)	14 (35%)	12 (30%)	5 (8%)
NO	32 (80%)	26 (65%)	28 (70%)	15 (25%)
9. Ave. distance from point of sale	0.33 km	0.22 km	0.20 km	0.88 km
10. Mode of payment				
Cash on delivery	31 (78%)		28 (70%)	20 (33%)
Credit	9 (23%)	40 (100%)	8 (20%)	
Installment			4 (10%)	

Table III.1 Mean soil moisture content after irrigation of rice paddy field for adjacent corn fields at different distances, MCIS, dry season, 1986.1/

Date/time	Left Corn Field2/ LC3	LC2	LC1	Rice Field	Right Corn Field RC1	RC2	RC3
May 5 0800	20.2a	20.5a	19.7a	20.2a	19.7a	21.5a	20.6a
May 5 1400	20.7ab	22.7ab	23.5b	27b	25.3b	24.2b	22ab
May 9 0800	22.6b	24.3b	26.9bc	28.5b3/	28.5bc	25.8b	22.8b
May 9 1400	22.9b	25.7b	27.5c	28.5b	27c	26.6c	23.2b
May 10 0800	23.5b	25.9b	28.1c	28.5b	27.3c	26.9c	23.3b

1/ Soil moisture was sampled at 60 cm depth.
Column means followed by the same letter are not significantly different at 5% level.

2/ LC3, LC2 and LC1 are 10m, 5m and 1m away from the edge of the rice paddy respectively, similarly for the right corn field. See Figure III.2 for details on the layout of the corn and rice fields.

3/ Constant moisture due to the standing or ponded water in the paddy

Table 111.2 Mean soil moisture content, fertilizer applied and yield of irrigated (through seepage) and rainfed hybrid corn at BARIS, dry season 1985-86.

Variety	MC% *	Fertilizer (kg/ha) N	P	K	Yield** (tons/ha
Irrigated Samples					
SMC	23	316	0	0	4.7
SMC	25	147	35	35	5.1
Pioneer	23	64	18	18	4.95
Pioneer	22	60	14	14	3.95
Pioneer	19	36	4	4	4.6
Pioneer	31	76	30	7.8	3.7
Cargill	19	81	26	0	4.9
Mean	23	111	18	11	4.55
Rainfed Samples					
SMC	13	114	30	0	3.15
SMC	14	154	80	0	1.45
SMC	15	141	33	33	2
Mean	14	136	48	11	2.2
Difference	9***	25	30***	0	2.35***.

* Mean soil moisture sampled at 40-60 cm depth
** Yield was sampled by crop cut 10m x 10m
*** Significant at 5%level using Lord's Range test for limited samples

Table III. 3 Mean duration, total water applied, critical irrigation flow and soil characteristics of Basin and Furrow irrigation methods at PTDF#2-ARIP, BARIS and MCIS dry season 1986.

Site	Irrigation Method	Soil Type	Critical Flow	Total Water Applied (mm)	Time of Irrigation1/	Differences
PTDF#2-ARIP	Basin	Sandy	10 lps	380	3.2 hrs	0.8 hrs.
	Furrow			242	2.4	
BARIS	Basin	sandy clay loam	15 lps	520	6.2 hrs	1.8 hrs.
	Furrow			384	4.4	
MCIS	Basin	sandy loam	15 lps	381	6.1	2.1 hrs2/
	Furrow			242	4.0	

1/ Mean duration of irrigating 1/4 ha of corn

2/ Significantly different at 10% level using LSD

Table III.4 Mean yield, water use, and labor use for double-row and triple row furrow irrigation methods for corn at CPPL IA and Sibester IA Study Sites, Isabela , dry season 1985-86.

Site	Yield (t/ha)	Total1/ water Applied (mm)	Labor Use for irrig- ation (man-days/ ha.)	Water Table Depth (m)
Sibester IA (San Mateo)				1.25
Double -row	4.79	43	3.47	
Triple-row	4.61	39	2.0	
CPPL IA (Luna)				2
Double-row	4.84	131	2.15	
Triple-row	4.46	120	1.23	

1/ Irrigation was only applied once at San Mateo site and three times at Luna site.

Table III.5 Total water applied, mean yield, labor use and field slope for white-bean crops using basin and furrow irrigation methods, SLBIP, Cavite, dry season 1985-86.

Irrigation Method	Total Water Applied Supplied1/ (mm)	Stored (mm)	Eff2/	Yield (t/ha) Actual	Labor3/ (MD)	Slope
1 Basin flooding	161.8	152.3	94.1%	0.99	0.5	0
2 Single furrow	132.6	109.0	82.2%	0.89	4.5	.25%
3 Double furrow	94.3	77.1	81.8%	1.18	4	.25%

1/ For basin flooding, rainfall (7 mm) was stored while none for the other two methods

2/ Efficiency = (Stored/Supplied)x 100%;does not account losses due to deep percolation

3/ Estimated labor use in irrigating the white bean crop in man-days/ha

Table III.6 Irrigation supplied and rainfall by division, at BARIS, wet season 1985.

Wk. No.	Date	Rain-fall (mm/wk)	Irrigation Diversion (mm/wk)			
			Total System	Division A	Division B	Division C
35	Aug 27–Sep 2, 1985	80	46	60	29	52
36	3–9	140	46	24	47	58
37	10–16	69	20	22	16	35
38	17–23	34	59	37	15	67
39	24–30	38	46	110	16	38
40	Oct 1-7	34	49	118	40	16
41	8–14	63	52	104	31	38
42	15–21	87	47	178	17	24
43	22–28	38	35	160	8	27
44	29-Nov 4	16	103	1735	41	76
Total		599	400	812	219	356
Mean		60	44	90	24	40

Means do not include week 44 due to unusually large water diverted for s area under irrigation towards the end of the season.

Table III.7 Relative water supply by division, at BARIS, wet season 1985.

Wk. No.	Date	Rain-fall (mm/wk)	Relative Water Sypply (RWS) Total System	Division A	Division B	Division C
35	Aug 27-Sep 2, 1985	79	1.55	1.56	1.18	1.85
36	3–9	140	2.32	1.95	2.11	2.73
37	10–16	69	1.1	1.11	0.98	1.32
38	17–23	34	1.09	0.85	0.57	1.16
39	24–30	38	0.98	1.76	0.63	0.85
40	Oct 1–7	34	1	1.82	0.86	0.54
41	8–14	63	1.56	2.42	1.22	1.19
42	15–21	87	2.07	4.46	1.56	1.49
43	22–28	38	1.19	3.79	0.75	0.91
44	29-Nov 4	15	1.54	23.5	0.77	1.15
Total		597				
Mean		59.7	1.43	2.19	1.10	1.34

Relative water supply = (Rainfall + Irrigation)/crop water requirement
Means do not include week 44 due to large water diverted to supply small area under irrigation at the end of the wet season.

Table 111.8 Irrigation water supplied and rainfall by division, at BARIS dry season 1985-86.

Wk. No.	Date	Rain-fall (mm/wk)	Irrigation Diversion (mm/wk) Total System	Division A	Division B	Division C
45	Nov 5–11, 1985	0	104	262	83	29
46	12–18	11	74	187	59	22
47	19–25	30	54	159	32	14
48	26–Dec 2	3	65	143	39	42
49	Dec 3–9	28	76	139	100	72
50	10–16	121	60	89	80	73
51	17–23	11	65	45	73	84
52	24–31	10	95	78	70	133
1	Jan 1–7, 1986	2	81	65	113	63
2	8–14	12	92	126	91	74
3	15–21	31	101	148	136	85
4	22–28	36	57	59	64	52
5	29–Feb 4	23	44	82	25	38
6	Feb 5–11	5	63	75	90	60
7	12–18	11	72	150	107	101
8	19–25	3	85	250	217	152
9	26–Mar 4	2	139	784	475	213
10	Mar 5–11	9	95			415
11	12–18	-	162			294
12	19–25	-	534			1070
Total		349	1103	1807	1159	941
Mean		**18**	**74**	**120**	**77**	**63**

Means and totals do not include weeks 9 to 12 due to small areas under irrigation at the end of the season.

Table III.9 Relative water supply by division, at BARIS, dry season 1985-86.

Wk. No.	Date	Rain-fall (mm/wk)	Relative Water Sypply (RWS) Total System	Division A	Division B	Division C
45	Nov 5-11, 1985	0	1.14	2.87	0.91	0.32
46	12-18	11	0.93	2.17	0.17	0.36
47	19-25	30	0.92	2.07	0.68	0.49
48	26-Dec 2	3	0.74	1.6	0.46	0.5
49	Dec 3-9	28	1.14	1.83	1.39	1.1
50	10-16	121	1.99	2.3	2.21	2.13
51	17-23	11	0.83	0.61	0.92	1.05
52	24-31	10	1.14	0.96	0.87	1.57
1	Jan 1-7, 1986	2	0.9	0.73	1.26	0.71
2	8-14	12	1.13	1.51	1.12	0.94
3	15-21	31	1.44	1.96	1.83	1.27
4	22-28	36	1.02	1.04	1.09	0.97
5	29-Feb 4	23	0.73	1.15	0.52	0.67
6	Feb 5-11	5	0.75	0.87	1.07	0.73
7	12-18	11	0.90	1.80	1.39	1.29
8	19-25	3	0.96	2.81	2.49	1.75
9	26-Mar 4	2	1.57	8.68	5.33	2.39
10	Mar 5-11	9	1.22			5.03
11	12-18	-	1.76			3.26
12	19-25	-	5.14			11.68
Total		349				
Mean		18	1.05	1.56	1.10	0.94

Means and total do not include weeks 8 to 12 due to small area under irrigation towards the end of the season

Table III.10 Comparison of irrigable areas (available flow converted to irrigable area, using 1.5 lps/ha as water duty) by sector BARIS, wet and dry season 1985-86.

Wk. No.	Date	Irrigable Area (has)						
(Prog.	Area, has)	Total System (1930)	Sector I (250)	Sector II (400)	Sector III (360)	Sector IV (300)	Sector V (350)	Sector VI (270)
35	Aug 27-Sep2	3000	500	550	318	600	0	500
36	3-9	3000	500	550	500	600	600	500
37	10-16	1377	0	363	377	550	600	305
38	17-23	1602	282	121	242	510	68	368
39	24-30	1377	485	138	200	179	92	225
40	Oct 1-7	1217	282	314	376	205	156	8
41	8-14	2300	500	449	235	428	37	426
42	15-21	3000	500	550	500	600	600	500
43	22-28	612	232	49	55	0	26	183
44	29-Nov 4	1041	348	151	75	241	135	177
45	Nov 5-11	1257	500	346	71	89	41	19
46	12-18	1025	424	279	60	212	30	21
47	19-25	984	374	201	65	336	21	0
48	26-Dec 2	818	307	168	5	258	40	41
49	Dec 3-9	1329	286	50	0	0	299	224
50	10-16	3000	500	550	550	550	550	500
51	17-23	900	146	344	0	103	262	222
52	24-31	1290	131	327	0	125	391	365
1	Jan 1-7	1001	194	480	0	0	155	172
2	8-14	1286	386	434	0	35	210	221
3	15-21	1865	354	400	0	0	300	350
4	22-28	1152	284	170	0	0	98	334
5	29-Feb 4	715	212	400	0	108	115	141
6	Feb 5-11	809	79	281	0	144	108	160
7	12-18	987	109	410	0	250	161	237
8	19-25	1069	162	405	0	202	205	217
9	26-Mar 4	1360	383	254	0	182	136	261
10	Mar 5-11	737	0	288	0	127	129	205
11	12-18	708	15	381	0	168	90	173
12	19-25	974	0	381	0	122	212	259
Mean		1393	283	326	121	231	196	244

Table III.12 Total water supply (irrigation + rainfall) Mani Communal Irrigation System, Dry Season 1985-1986.

Week No.	Date	RF (mm/wk)	IR (mm/w) Total (240)	Section A(132)	Lateral B(108)
	Programmed Area (ha)				
45	Nov 5-11,	2	75	68	84
46	12-18	1	90	52	135
47	19-25	14	103	102	104
48	26-Dec 2	14	16	29	0
49	Dec 3-9	40	89	56	130
50	10-16	6	85	53	125
51	11-23	36	43	17	73
52	24-31	5	96	79	117
1*	Jan 1-7, 1986	3	65	48	84
2	8-14	21	73	21	136
3	15-21	29	21	9	35
4	22-28	148	0	0	0
5	29-Feb 4	7	0	0	0
6	Peb 5-11	15	80	56	67
7	12-18	11	97	28	88
8	19-25	11	65	8	118
	Dry Season Mean	20	63	51	80

* Programmed areas was reduced to 150, 36, and 114 ha, for the Total System, Section A and Lateral B respectively onward from week 1 to week 8.

Table III.13 Weekly irrigation diversion requirement (I
irrigation water supplied (IR), rainfall (
relative water supply (RWS), Magat River I
District II, Lateral A, dry season 1985-86.

Week No.	Date	IDR (mm/wk)	IR (mm/wk)	RF (mm/wk)	RWS
40	Oct 1–6 1985	256	213	21	0.91
41	7–13	244	213	13	0.93
42	14–20	206	124	146	1.31
43	21–27	220	75	145	1
44	28–Nov 3	257	214	63	1.08
45	Nov 4–10	209	234	30	1.26
46	11–17	207	244	20	1.28
47	18–24	201	251	34	1.42
48	25–Dec 1	198	249	41	1.46
49	Dec 2–8	188	250	44	1.56
50	9–15	185	257	5	1.42
51	16–22	176	260	9	1.53
52	23–29	174	261	7	1.54
1	30–Jan 5	172	255	1	1.49
2	Jan 6–12	179	248	8	1.43
3	13–19	173	252	7	1.5
4	20–26	178	249	12	1.47
5	27–Feb 2	178	236	52	1.62
6	Feb 3–9	186	234	3	1.27
7	10–16	187	248	2	1.34
8	17–23	187	243	0	1.3
9	24–Mar 2	187	231	9	1.28
10	Mar 3–9	173	223	3	1.31
11	10–16	114	201	24	1.97
12	17–23	102	177	0	1.74
13	24–30	79	167	12	2.27
14	31–Apr 6	60	163	0	2.72
15	Apr 7–13	52	116	23	2.67
	Mean	175	217	26	1.5

IDR = Irrigation Diversion Requirement
IR = Actual Irrigation Delivered
RF = Rainfall
RWS = Relative Water Supply = (IR + RF) / IDR

Table III.14 Summary of the costs and returns of the tested alternative non-rice crops at Allah Valley site, dry season 1985-86.

Crop/Site	Yield (kg/ha)	Gross a/ Returns	Production b/ Costs	Net Returns
Corn	(rhrllrd)			
PTDF#2	588 c	1586	2924	-1338
BARIS	2240	6048	3596	2452
MCTB	2660	7182	3728	3454
Peanut	(rhrllrd)			
PTDF#2	1988	14200	5708	8492
BARIS	1120	8000	493s	3067
MCIB	1400	10000	5183	5817
Mungbean	(rhrllrd)			
PTDF#2	0 d	0	1249	-1249
BARIS	1320	6600	4979	1621
MCIS	1742	8710	5330	3380

a Gross income in Peso8
b Production cost6 do not include land rent
c Low yield due to pest and disease infestation and low soil OM
d Zero yield due to water-logging inducing nematode and viral leaf infestation

Table III.15 Means of bean, and pod yields of peanut planted at San Mateo and Luna, Isabela, dry season 1986.

Site	Bean Yield (t/ha)		Pod Yield (t/ha)		No. of pods/plant	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
San Mateo	1.52	1.08	2.28	1.65	20	10
Luna	1.00	0.70	1.52	0.90	18	16

Table 111.16 Input and Output cost of production for White Beans. Thirteen sample farms, Cavite, Dry Season 1985-86.

Sample Area (ha)	Production (kg)	Production Value (P)	Production Costs (P) Fert.	Pest.	Other*	Total	Net Returns (P)
0.4	686	8924	832	350	1889	3071	5853
0.5	506	6578	957	654	1834	3445	3111
0.4	404	5252	700	741	1333	2774	2478
0.3	296	3835	592	525	1618	2735	1100
0.2	181	2353	440	368	880	1688	665
0.2	157	2041	275	350	887	1512	529
0.2	127	1651	475	-	677	1151	500
0.4	228	2957	400	570	1553	2523	434
0.3	73	949	375	315	1013	1703	-754
0.2	106	1372	950	525	832	2306	-935
0.5	225	2925	540	1060	2304	3904	-979
0.3	25	325	-	165	1448	1613	-1288
0.5	148	1924	1183	490	1688	3341	-1417

* Other consists of seed, fuel, miscellaneous and hired labor costs.

Table 111.17 Total water use and mean yields for two varieties of corn and three irrigation treatments at San Mateo, Carulay and Luna sites, Isabela, dry season, 1985-86.

Site	Total Water Use (mm)1]				Mean Yield (ton/ha) 2]					
	Irrigation			Rainfall	Variety 1			Variety 2		
	I	II	III		I	II	III	I	II	III
San Mateo	24	25	18	187	5.27	5.67	5.54	6.24	5.92	5.60
Carulay	158	142	253	171	5.27	4.02	5.17	5.65	4.73	5.98
Luna	182	145	178	240	4.47	2.89	4.21	6.09	5.04	5.59
Mean					5.00	4.19	4.97	6.00	5.23	5.72

1] Irrigation treatments were:
- I - irrigation applied at: a)tasseling, b)silking and c) grain filling stages.
- II - irrigation applied at a)tasseling and c) grain filling stages.
- III- irrigation applied only at 50X soil moisture depletion.

2] Varieties used were:
- Variety 1 - IPB Var 2 - open pollinated white flint.
- Variety 2 - pioneer 6181 Var 2 - Yellow hybrid.

Table 111.18 Crop coefficients for consumptive use of corn computed from soil moisture data at Catulay site. Echague, Isabela, Dry Season, 1986.

Stage of Crop Growth	Crop Coefficient
Emergence to Tasseling	0.8
Tasseling to Flowering	1.0
Flowering to Grain Formation	1.3
Grain Formation Period	1.1
Grain Maturity Period	0.4

Table III.20 White-bean crop coefficients (kc) as determined at UPLB, Experiment Station,* dry season 1985-86.

Growth Stage DAS	Kc			
11-20	0.81	>	0.86	vegetative
21-30	0.92			
31-40	1.10			
41-50	1.00	>	1.08	reproductive
51-60	1.08			
61-73	0.73	>		bean filling

*

Table III.21 Mean weight of dry seeds of white beans flooded at different growth stages and at varying durations, UPLB Experiment Station, dry season 1985-86.

Flooding Duration (days)	Dry seed weight in grams per pot		
	15 DAS*	30 DAS	45 DAS
0	75 a	75 a	75 a
1/2	71 ab	53 c	78 a
1	67 ab	57 c	71 ab
2	51 c	55 c	57 c
4	39 d	3 f	55 c
6	37 d	2 f	55 c
10	21 e	3 f	60 c

* DAS - days after seeding

Means with the same letter(s) are not significantly different at 1 % level.

Table III.22 Comparison of rice yields and costs of production of irrigated rice-rice, irrigated rice-corn and irrigated rice-rice/corn cropping patterns at BARIS, dry season 1985-86.

	CROPPING PATTERN		
	RR	R-RC	R-C
No. of samples	77	15	10
Ave. farm area (ha.)	1.40	1 28	0.02
1. Yield (kg/ha)	4,199	2,774	3,472
2 Price (P)	2.60	2.21	2 26
3. Output Value (P/ha)	11,205	6,036	7,902
4 Current Inputs			
Fertilizer	889	909	532
Pesticides	369	21	31
Seeds	543	460	531
Equipment Rental	1,096	480	449
Other Cash Outlay	29	14	70
Total Inputs	3,151	1,883	2,265
5. Hired Labor Cost	1,450	792	856
6. Land Rental Payments	1,316	406	553
7. Irrigation Fee	544	0	0
8. Total Family Labor	1,643	1,063	1,365
Returns to family resources (P/ha) before labor	4,745	2,955	4,229
Returns to family resources (P/ha)	3,102	1,891	2,864

RR - rice for both wet and dry seasons
R-RC - rice for wet and rice and corn for dry season
R-C - rice for wet and corn for dry season

Table III.23 Comparison of yields and costs of production of irrigated rice and hybrid corn at BARIS, dry season 1985-86.

	Rice	Hybrid Corn	Difference	
No. of Samples	77	15		
Ave. farm area (ha.)	1.41	1.13		
1. Yield (Kg/ha)	4,199	3,673	525	ns
2. Price (P)	2. 52	2.26	0. 26	
3. Output value (P/ha)	10,585	8,234	2,351	**
4. Current Inputs (P/ha)				
Fertilizer	843	1,369	(525)	**
Pesticides	359	35	323	**
Seeds	516	773	(257)	**
Equipment Rental	1,045	631	413	**
Other Cash Outlay	27	10	17	ns
Total Farm Inputs	3,002	2,820	181	ns
5. Hired Labor Cost	1,396	964	432	**
6. Land Rental Payments	1,208	463	470	ns
7. Irrigation Fee	540	0	540	**
8. Total Family Labor	1,561	1,090	470	ns
Total Production Cost	7,709.	5,339	2,370	**
Return to family resources (P/ha) before labor	4,437	3,985	452	ns
Return to family resources (P/ha)	2,875	2,894	(18)	ns

** = Significant at 1%, * = Significant at 5%,
ns = Not significant

Table III.24 Mean yield, input coats of production and returns to family resources for irrigated hybrid, open-pollinated and rainfed hybrid corn at BARIS, dry season 1985-86.

	Hybrid Corn Irrigated	Hybrid Corn Rainfed	Open Polinated Irrigated
No. of samples	15	13	lo
Average farm area (ha.)	1.13	1 38	1.05
1 Yield (kg/ha)	3673	2926	2122
2 Price (P)	2.36	2 32	2 18
3 Output value (P/ha)	8234	6765	4605
4 Current input (P/ha)			
Fertilizer	1369	1412	493
Pesticides	35	30	8
Seeds	773	766	61
Equipment Rental	631	599	220
Other.Cash Outlay	10	15	75
Total farm inputs	2820	2824	859
5 Hired labor cost	964	973	596
6 Land rental payments	463	853	466
7. Irrigation fee	0	0	0
8 Total family labor	1090	932	1324
Total Production Cost	5339 .	5584	3246
Returns to family resources (P/ha) before labor	3985	2113	2683
Returns to family resources (P/ha)	2894	1181	1359

Table III.25 Comparison of input and labor costs for irrigated rice, hybrid corn and rainfed hybrid corn at BARIS, dry season 1985-86

	Rice	Hybrid Corn Irrigated	Hybrid Corn Rainfed
No. of samples	77	15	13
Average farm area (ha.)	1.41	1.13	1.38
1. Yield (Kg/ha)	4,199	3,673	2,926
2. Ave. price (P/kg)	2.52	2.26	2.32
3. Output value (P/ha)	10,585	8,234	6,765
4. Total Input (P/ha)	3,002	2,820	2,824
% Total Input Cost Output Value	28%	34%	42%
5. Hired labor (P/ha)	1,396	964	973
6. Family labor (P/ha)	1,561	1,090	932
Total labor Costs (P/ha)	2,958	2,055	1,906
% Total labor Cost/ Output Value	28%	25%	28%

Table III.26 Comparison of yields and costs of production of irrigated rice and rainfed hybrid corn at MCIS, dry season 1985-86.

	Rice Irrigated	Hybrid Corn Rainfed	Difference	
No. of Samples	48	8		
Ave. farm area (Ha.)	1 42	1 50		
1 Yield (Kg/ha)	4,222	3,233		
2 Price (P)	2.69	2 64		
3 Output Value (P/ha)	11,379	8,601	2.777	*
4. Current Inputs				
Fertilizer	490	850	(359)	**
Pesticides	223	126	97	ns
Herbicides	181	0	181	**
Seeds	412	342	70	ns
Equipment Rental	971	679	291	*
Other Cash Outlay	78	0	78	ns
Total Farm Inputs	2,358	1, 998	359	ns
5 Hired Labor Cost	376	16	360	ns
6. Land Rental Payments	580	181	399	ns
7. Irrigation Fee	338	0	338	**
8. Total Family Labor	1,939	1, 707	232	ns
Total Production Cost	5,593	3,903	1,690	**
Returns to family resources (P/ha) before family labor	7, 724	6,405	1,319	ns
Returns to family resources (P/ha)	5,785	4,698	(1,087)	ns

** = Significant at 1%, * = Significant at 5%,
ns = Not significant

Table III.27 Mean input and output of production for irrigated rice and corn at SIBESTER IA area, Isabela, dry season 1985-86

	Rice	Corn
No of samples	11	5
Average area (ha)	0.69	0.6
Average Yield (kg/ha)	5015	10826 (unshelled)
Total Receipts (P/ha)	12689	12018
Production Cash Inputs (Paid before harvest)		
Fertilizer	1175	1338
Seeds	445	740
Insects/herbicides	473	715
Hired labor	2307	974
Total Cash Inputs	4400	3767
Non-Cash Inputs (Paid after harveat)		
Land rent	1246	-
Irrigation fee	572	-
H/T share	963	-
Creditor's share	1474	-
Others	655	751
Family labor	1072	344
Exchange labor	386	-
Total Production Inputs	10769	4862
Returns to Family Resources (P/ha)	1920	7150

Table III.28. Comparison of farm gate prices of rice and corn at SIBESTER San Mateo, Isabela, 1980-86.

Year/Season	Price/kg Rice	Price/kg Corn (shelled)*	Difference
1980-81			
Dry	1.54	1.41	0.13
Wet	2.57	1.52	1.05
1981-82			
Dry	2.69	1.6	1.09
Wet	2.76	1.78	0.98
1982-83			
Dry	2.92	2.36	0.56
Wet	2.79	2.39	0.40
1983-84			
Dry	3.07	2.67	0.40
Wet	3.13	2.41	0.72
1984-85			
Dry	3.32	1.72	1 60
Wet	3.50	1.50	2.00
1985-86			
Dry	2.53	2.10	0.43

* Price of unshelled corn ranges from 40-50% that of the shelled dry corn.

Table III.29 Average number of years associated with the Irrigators' Association

	ARIP	BARIS	MCIS
Total number of respondents	51	45	54
Average number of years associated with IA	1.29	2.60	12.33

Table III.30 Working relations assessment among members with IA officers, NIA and other agencies' staff.

Working Relation Assessment	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
1. Between officers and members of the association						
a. poor	2	4	0	0	17	32
b. good	49	96	40	87	37	68
c. excellent	0	0	6	13	0	0
d. did not answer	0	0	0	0	0	0
Total	51	100	46	100	54	100
2. Between IA officers and NIA personnels						
a. poor	2	4	0	0	0	0
b. good	49	96	42	91	54	100
c. excellent	0	0	4	9	0	0
d. did not answer	0	0	0	0	0	0
Total	51	100	46	100	54	100
3. Between IA officers and MAF/other agency workers						
a. poor	2	4	1	2	0	0
b. good	48	94	39	85	54	100
c. excellent	0	0	6	13	0	0
d. did not answer	1	2	0	0	0	0
Total	51	100	46	100	54	100
4. Between IA officers and barangay officials						
a. poor	2	4	0	0	0	0
b. good	49	96	37	80	54	100
c. excellent	0	0	9	20	0	0
d. did not answer	0	0	0	0	0	0
Total	51	100	46	100	54	100

Table 111.31 Problems presently affecting the Irrigators' Association

PROBLEMS	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
1. Members lack of interest in IA activities (meetings, other activities)	13	22	12	26	9	16
2. Inadequate water supply, unequal distribution of water, lack of irrigation structures (turnouts, gates, etc)	14	24	12	25	34	62
3. poor irrigation fee collection	1	2	0	0	1	2
4. poor management (non implementation of policies, no meeting conducted, weak leadership	1	2	0	0	4	7
5. others (marketing problem lack of drainage facilities, inadequate funding sources	2	3	2	4	1	2
6. insufficient and destroyed farm roads and poor drainage	15	25	0	0	0	0
7. did not answer	13	22	21	45	6	11
Total	59	100	47	100	55	100

Respondents gave more than one answer

Table III.32 Specific responsibilities of IA members to the association.

Responsibilities	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
1. Attending meetings	36	42	5	8	18	23
2. Communal works (cleaning, repair and maintenance. of canals)	5	6	9	14	9	12
3. Paying irrigation fees, contributions, and giving financial assistance to the'association	35	40	16	25	36	47
4. Obeying policies, programs and plans of the IA activities (cooperating in all IA activities)	11	13	31	49	13	17
5. Helping in planning, decision making and solving problems of the association	0	0	2	3	1	1

Table III.33 Activities in which the IA members do to undertake the operations and management of the irrigation system.

Physical Work	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
1. Communal works (cleaning, repair and maintenance of canals)	50	98	36	64	53	98
2. Cooperating in all IA activities (obeying policies, programs and plans of the association)	0	0	9	16	0	0
3. Helping in building FIA center	0	0	10	18	0	0
4. Did not answer	1	2	1	2	1	2
Total	51	100	56	100	54	100

Respondents gave more than one answer

Table III.34 Benefits derived by members from the IA

Benefits	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
I. Increased income and production	31	35	24	28	30	35
2. Improved standard of living	6	7	1	1	19	22
3. Sufficient water	40	55	24	28	34	40
4. Personality development, human relation (goad relationship among members, unity)	0	0	16	19	1	1
5. Facilitated farm operation	0	0	5	6	0	0
6. Additional knowledge and technology	1	1	16	18	0	0
7. Others (request is easier, inputs/financing aid)	0	0	1	1	0	0
8. Did not answer	2	2	0	0	2	2
Total	88	100	87	L00	86	100

Respondents gave more than one answer

Table III.35 Willingness of farmers to plant other crops aside from rice during the dry season.

	ARIP N	ARIP %	BARIS N	BARIS %	MCIS N	MCIS %
1. Are you willing to plant other crops aside from rice during the dry season?						
a. Yes	43	84	23	50	46	85
b. No	8	16	23	50	8	15
Total.	51	100	46	100	54	100
2. If yes, which crop would you prefer?						
1. corn	42	64	18	33	44	45
2. mongo	13	20	13	24	30	30
3. peanut	3	4	0	0	4	4
4. cotton	0	0	0	0	7	7
5. others (eggplant, waternelon, sweet potato, cassava).	0	0	1	2	6	6
6. not applicable	8	12	23	41	8	8
Total	66	100	55	100	99	100
3. If no, what are your reasons?						
1. Had been used to palay and is our staple food	0	0	4	8	0	0
2. Farm is a lowland area and not suitable for upland crops	7	14	16	30	2	4
3. poor drainage	1	2	8	15	6	11
4. limited supply of water during the dry season	0	0	1	2	0	0
5. not applicable	43	84	24	45	46	85
Total	51	100	53	100	54	100

Respondents gave more than one answer

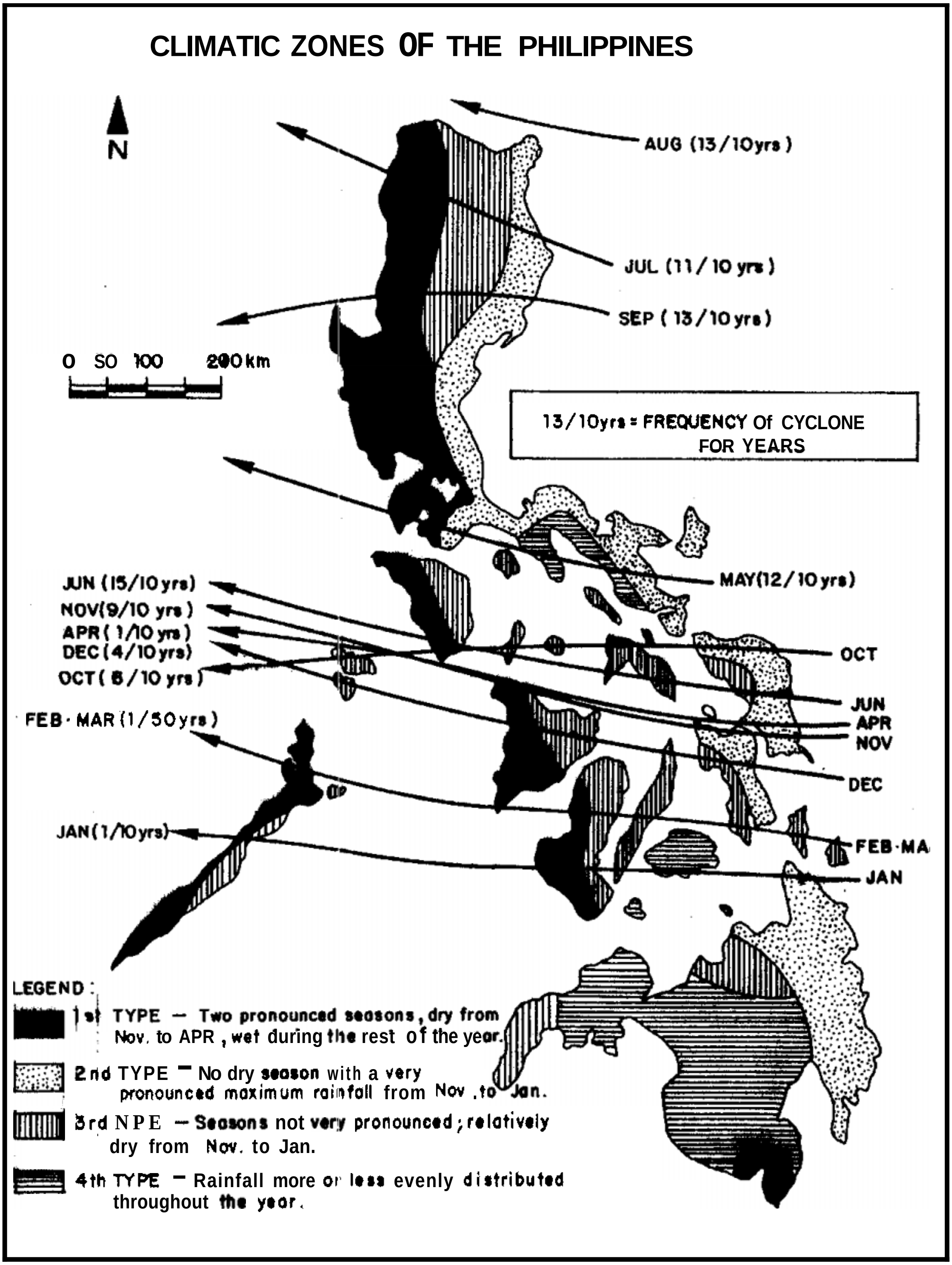


Figure 1.1 Climatic zones of the Philippines

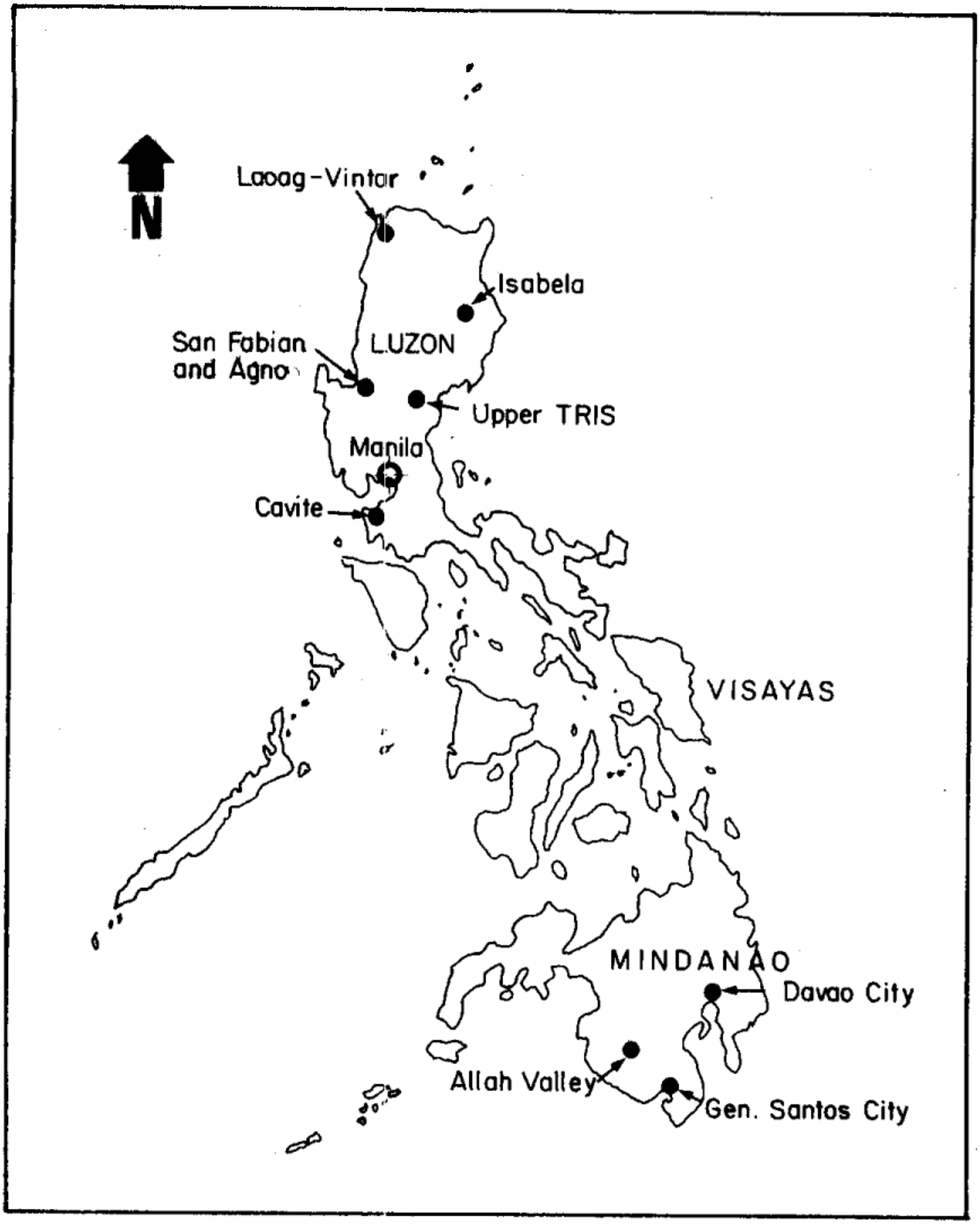


Figure 1.2 Map of the Philippines showing sites of the study.

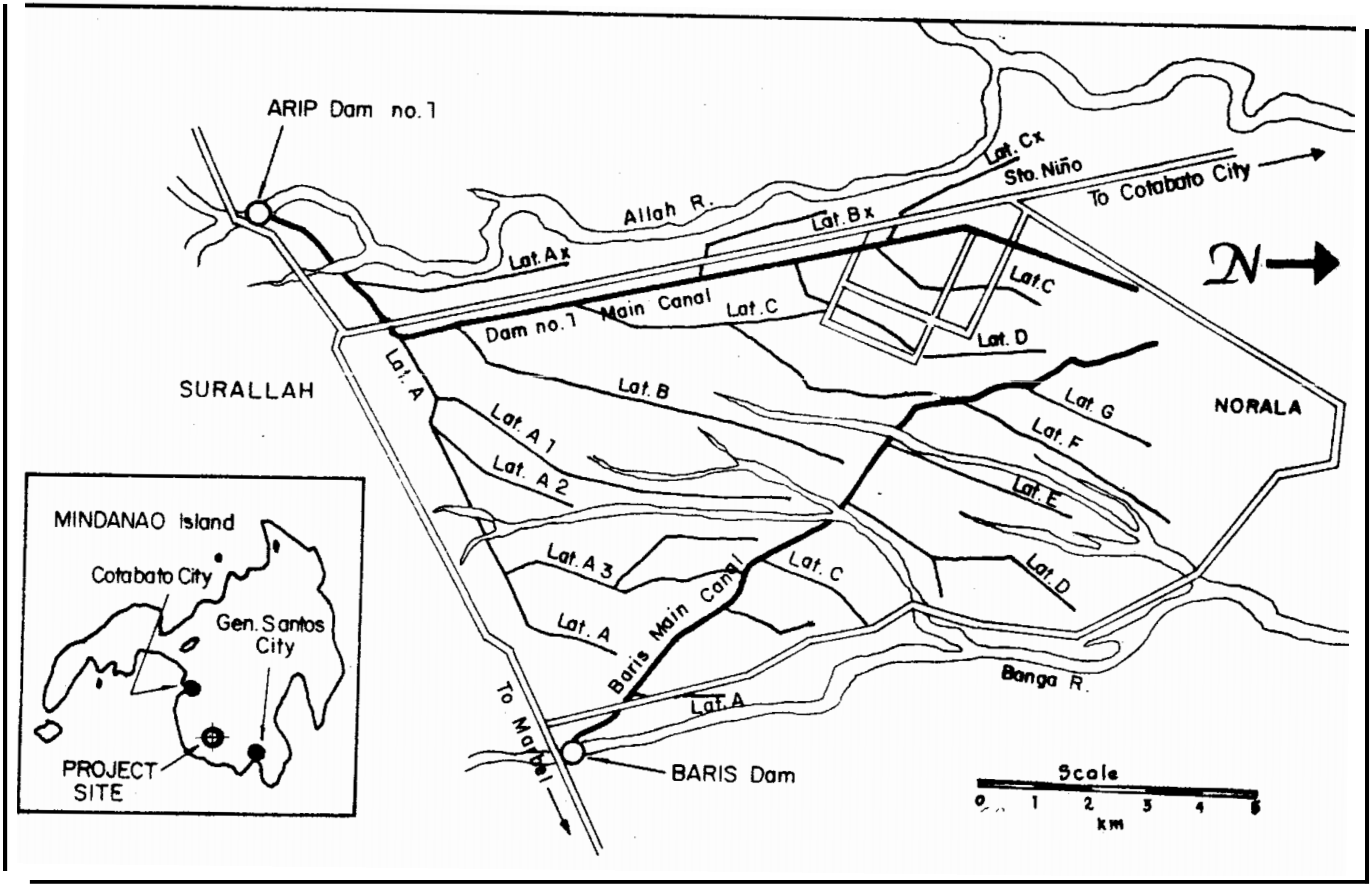


Figure 11.1 Irrigation canal networks of the Allah River Irrigation System (ARIP) Dam 1 and Banga River Irrigation System (BARIS), South Cotabato.

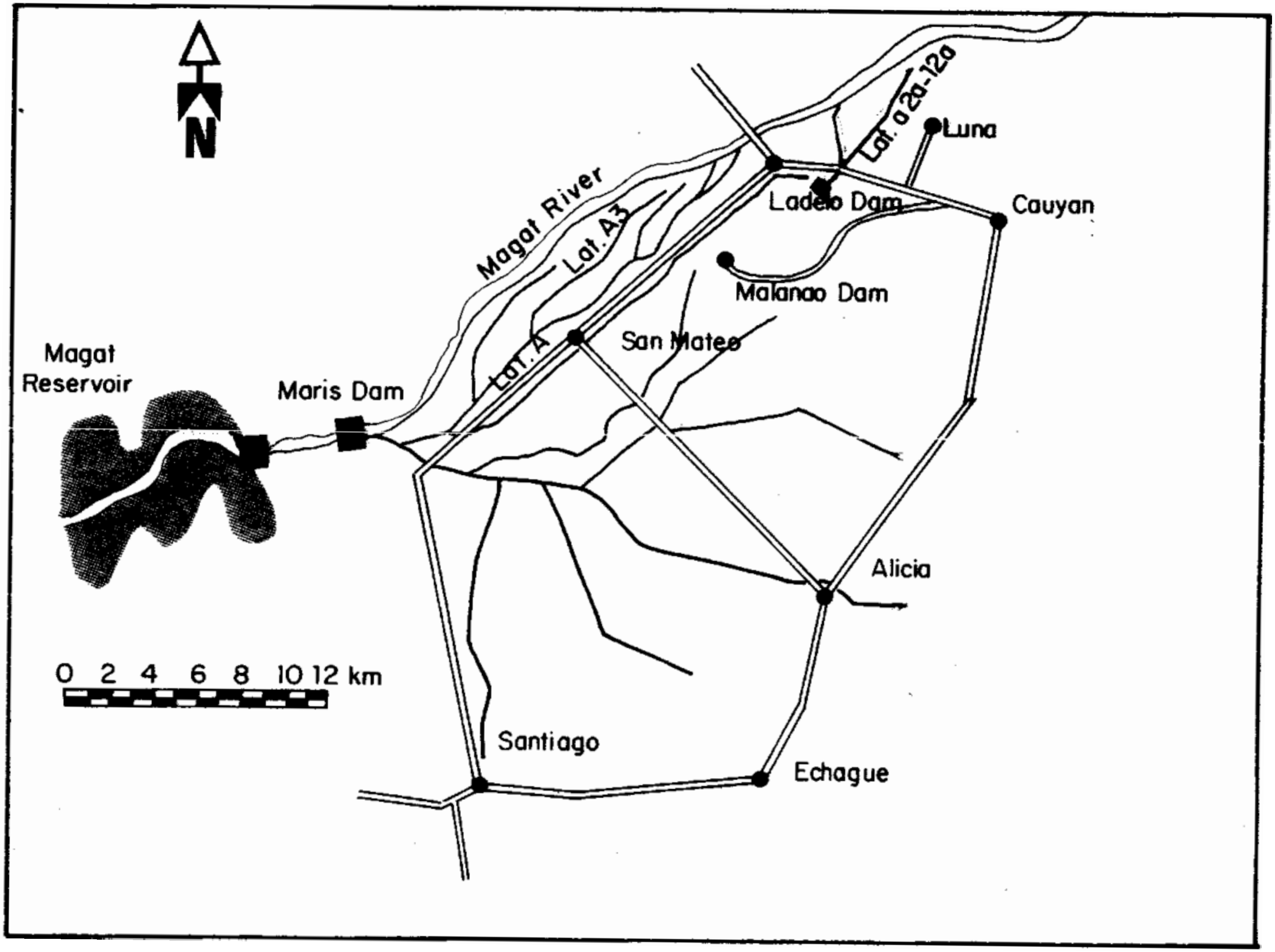


Figure II.2 Map of the Magat River Irrigation System showing the study laterals.

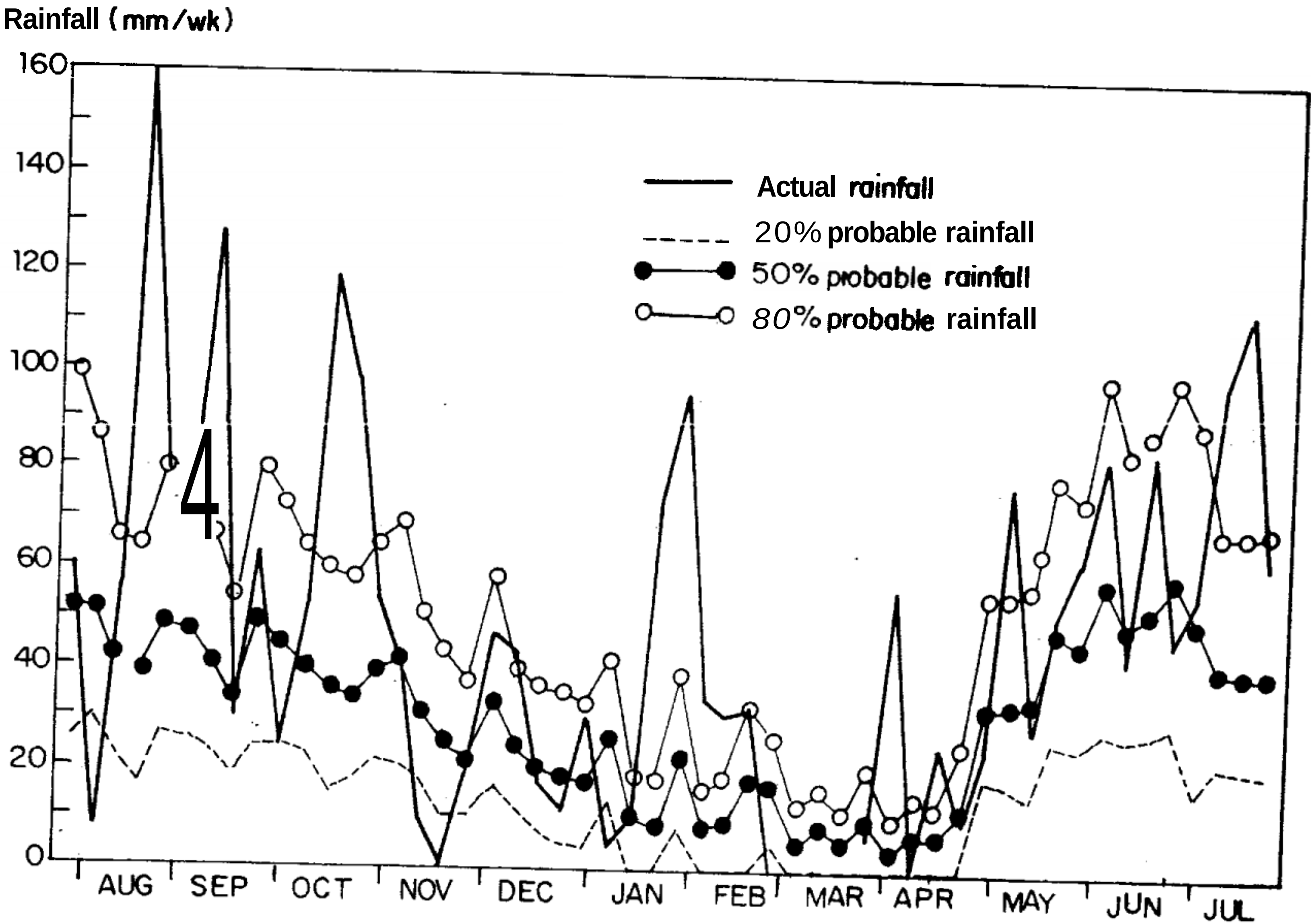


Figure III.1 Weekly rainfall (actual 1985-86 rainfall and probabilities at 20%, 50% and 80% based on 18-year rainfall record) at Allah Valley, South Cotabato.

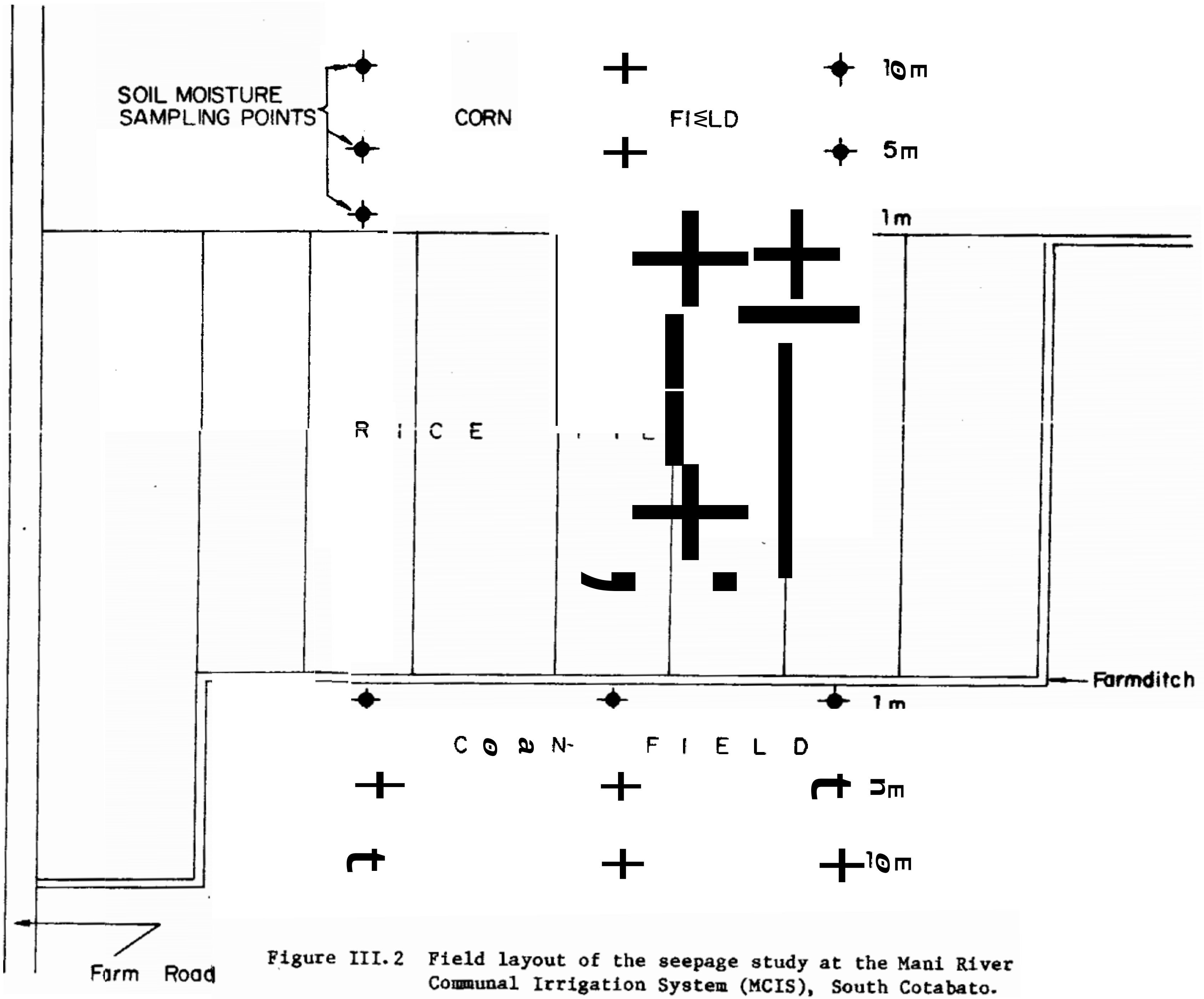
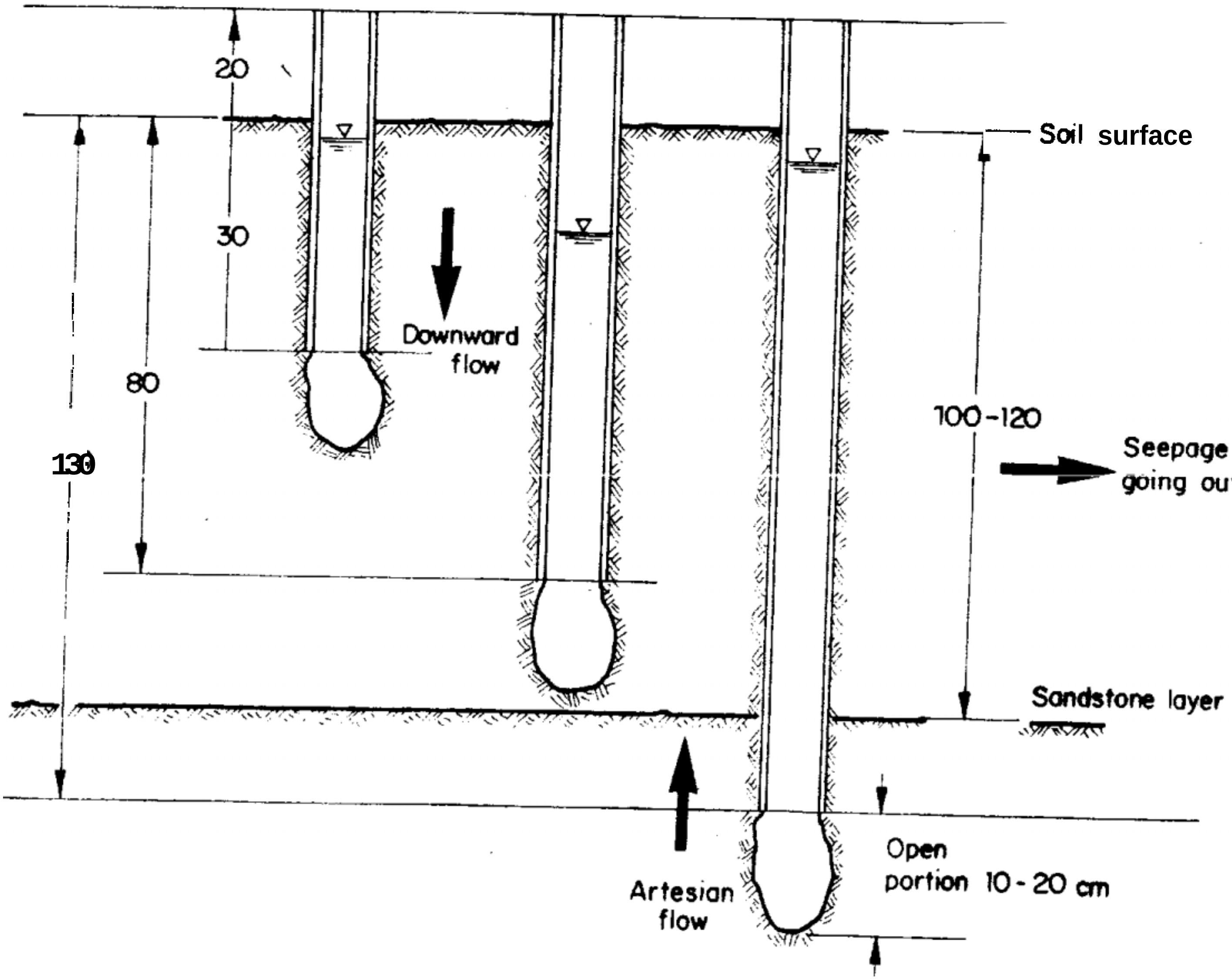


Figure III.2 Field layout of the seepage study at the Mani River Communal Irrigation System (MCIS), South Cotabato.



General behavior of water level in piezometers at MCIS .

Figure 111.3 Schematic representation *of* the piezometer set-up for the seepage study, showing the influence of the "sandstone" like layer at MCIS, South Cotabato.

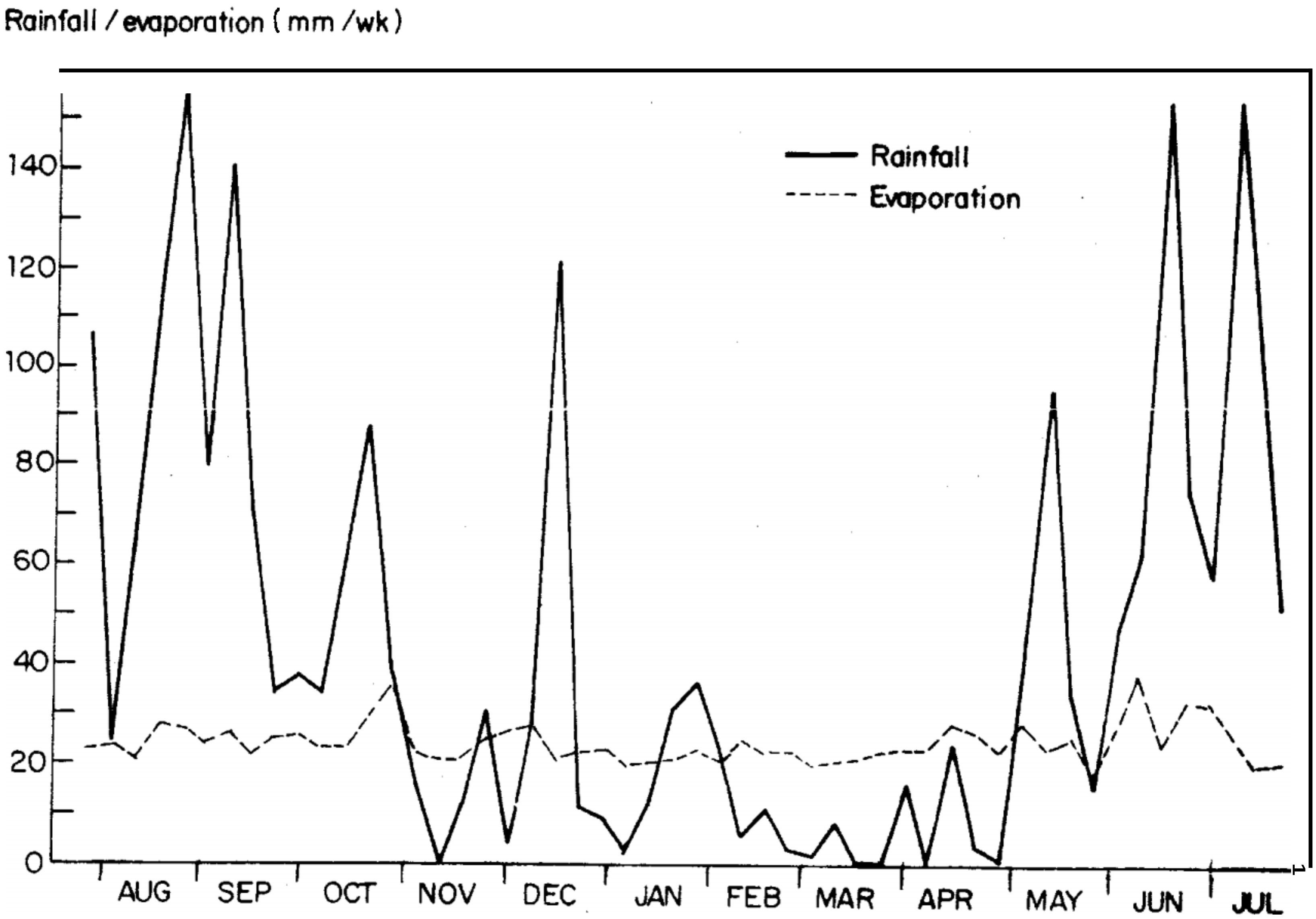


Figure III 4 Weekly rainfall and evaporation at BARIS South Cotabato, wet and dry seasons 1985-86.

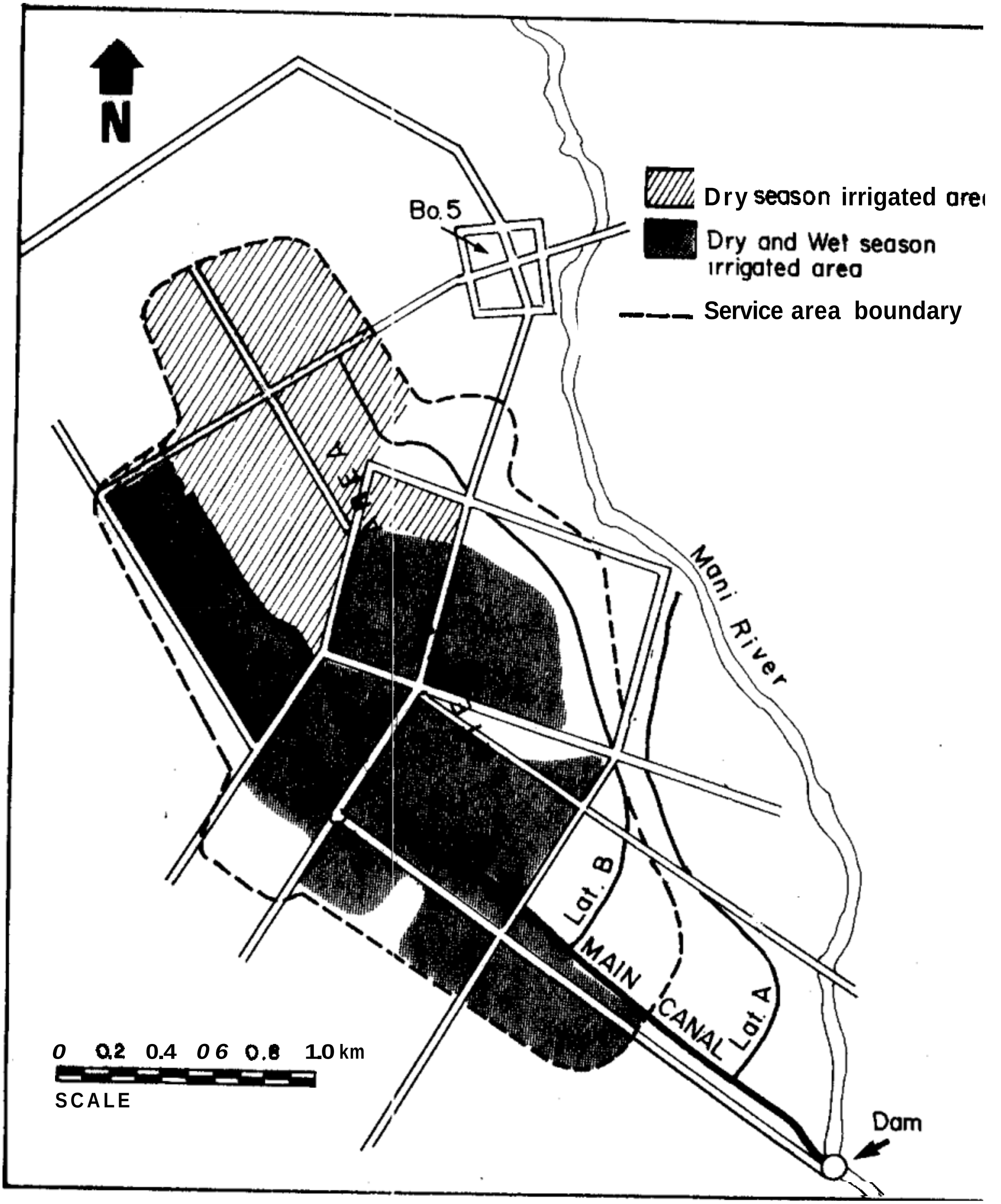


Figure 111.5 Map of the Mani River Communal Irrigation System (MCIS).

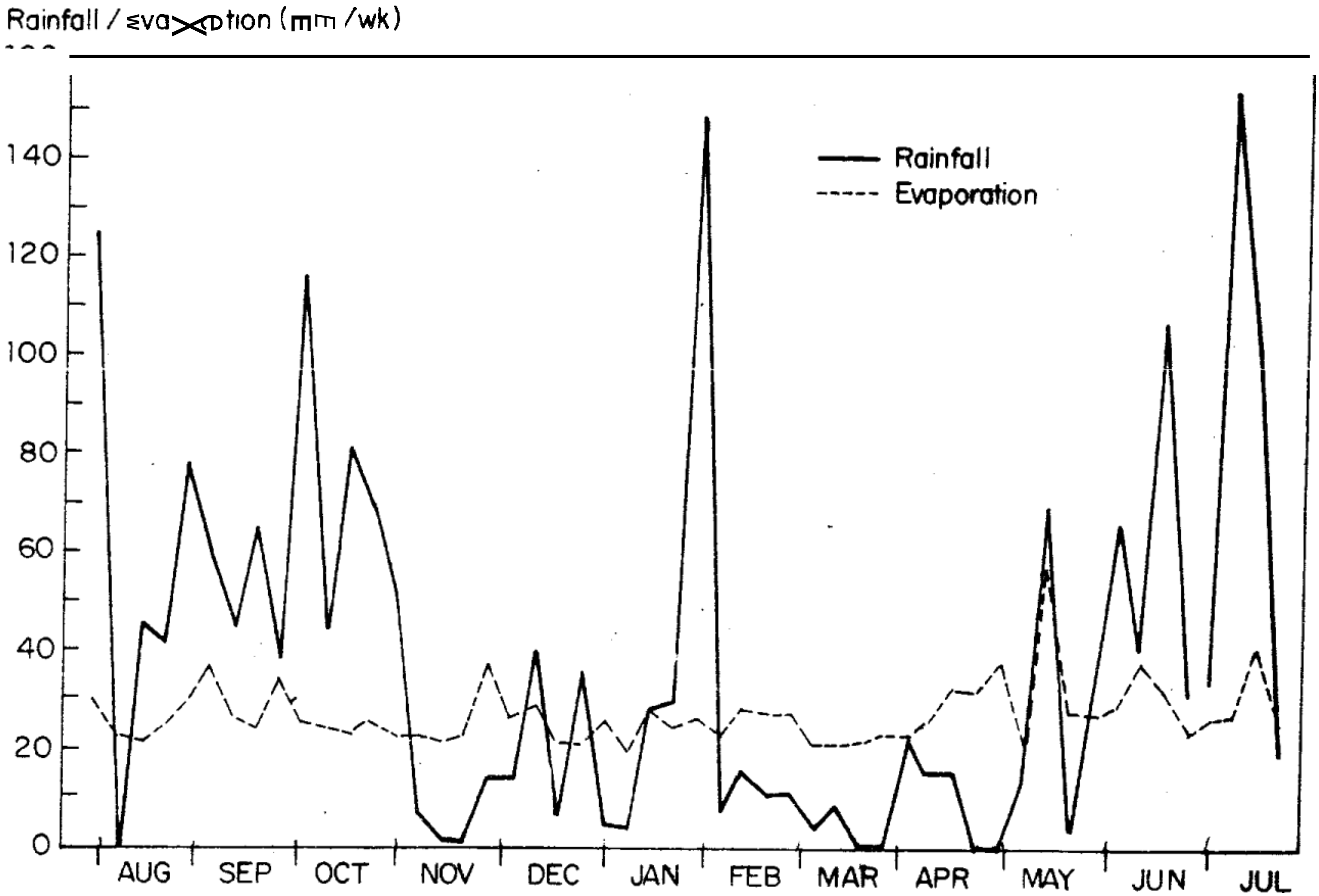


Figure III.6 Weekly rainfall and evaporation at MCIS, South Cotabato, wet and dry seasons 1985-86.

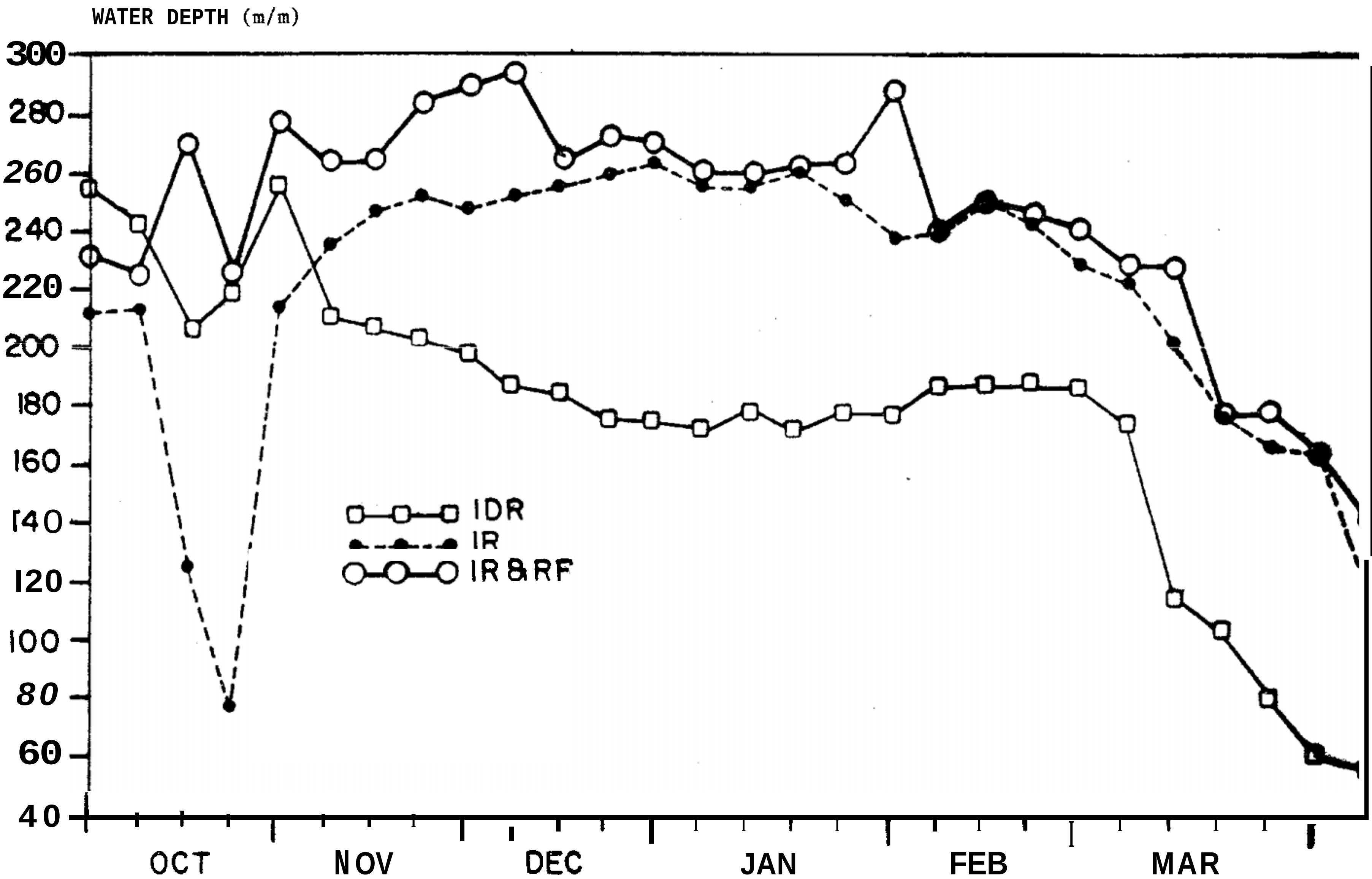


Figure 111.7 Irrigation requirement (IDR), irrigation water supplied (IR) and rainfall (RF) at MARIS, lateral A, Isabela, dry season 1985-86.

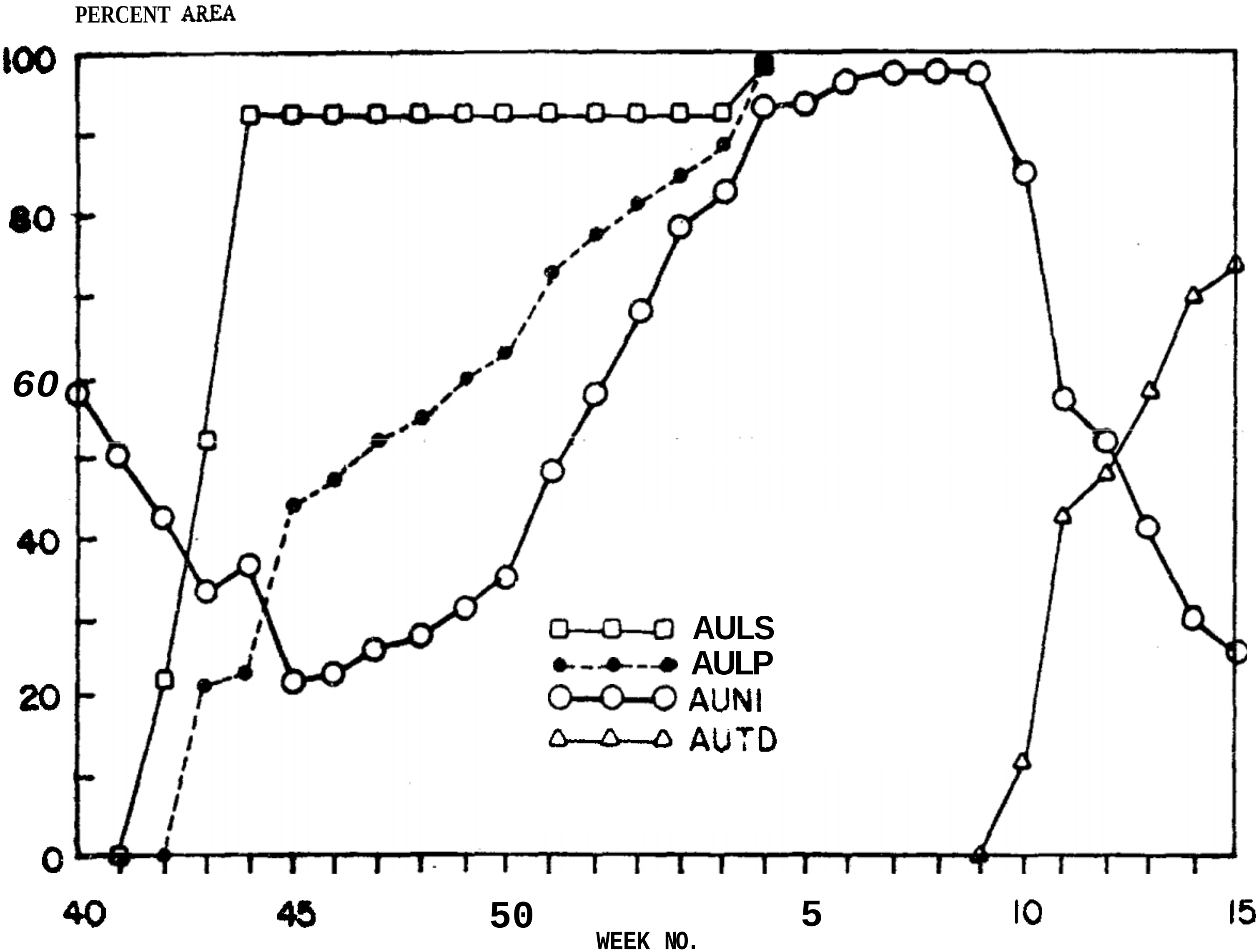


Figure 111.8 Percent areas land soaked (AULS), land prepared (AULP), land irrigated for crop growth (AUNI) and land drained (AUTD) at MARIS, lateral A, dry season 1985–86.

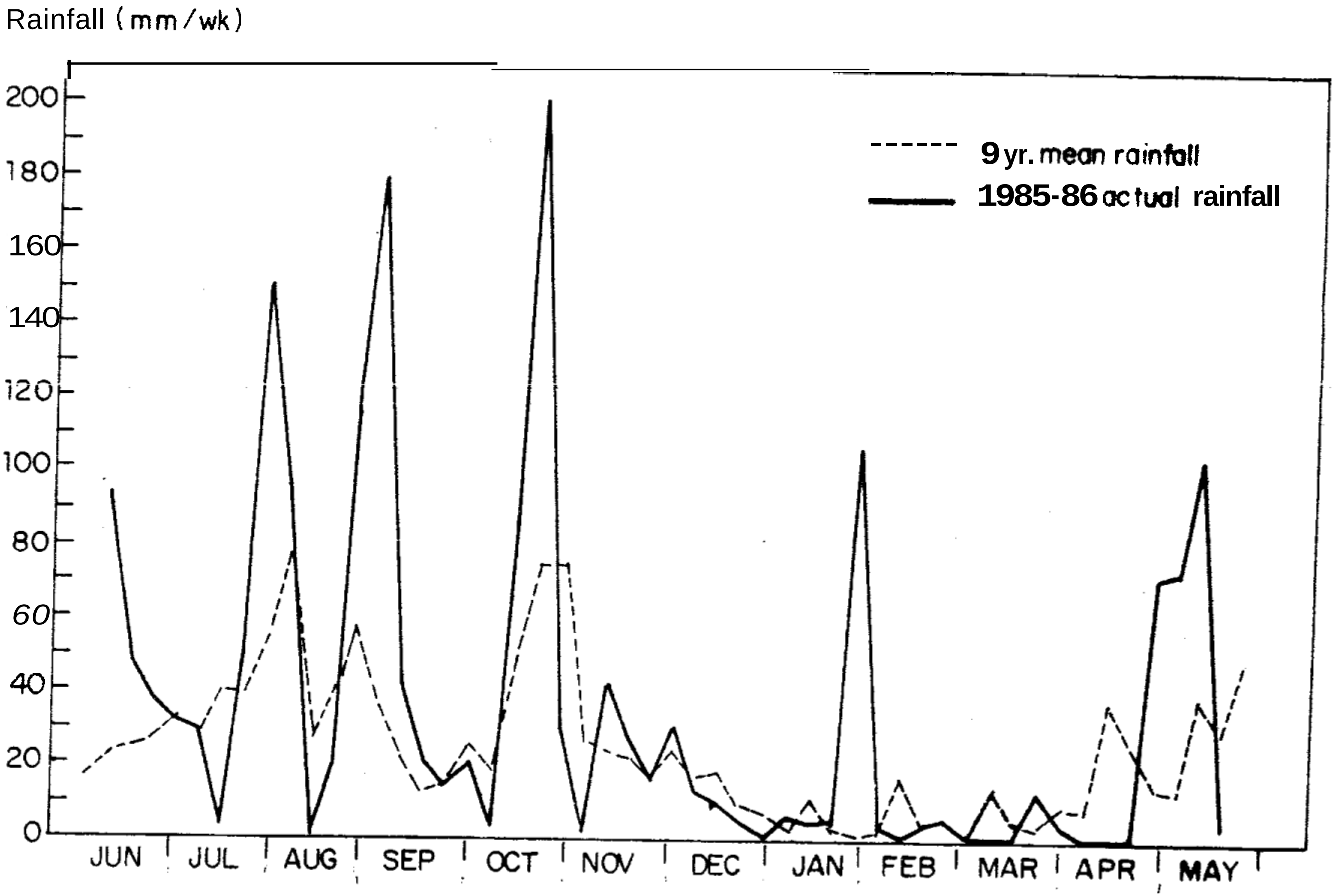


Figure 111.9 Weekly rainfall (actual 1985–86 and 5-year mean rainfall) at Echague, Isabela.

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ANNEX I. BANGA RIVER IRRIGATION SYSTEM (BARIS)

1-1 The BARIS is a run-of-the river type irrigation system. The dominant problem is the high amount of silt contained in the river flow. To minimize the silt intake, the spillway gates are opened daily for two hours to clear the entrance to the main channel. This system also has a silting basin into which the water is diverted before entering the main canal. Despite these measures, the main canal still carries a high concentration of silt and this necessitates desilting the main canal and laterals during April.

1-2 The whole system is headed by an Assistant Irrigation Superintendent and is divided into three Water Master Divisions. The system has nine IA areas. For water distribution purposes the system is divided into six hydrologically separate sectors. These sectors are grouped into corresponding WMT Divisions (A, B, and C). The sectors with their different areas and other descriptions are presented in the following table.

Sector Group	Irrigable Area	WMT Division	No. of IA Covered	Laterals Covered
I	250	1(A)	4	A, B, C
II	400	2(B)	1	D
III	360	1(A)	1	E
IV	300	1 & 2 (C)	1	main canal (E-F)
V	350	3(C)	1	F
VI	270	3(C)	1	G
TOTAL	1,930	3(C)	9	7

1-3 The reported irrigable area has been reduced to only 1,930 ha from 2,300 ha because of limited available water supply. The nine IAs covering the area were federated into one in September 1985 and became a chapter of the South Cotabato and General Santos Federation of Farmers Irrigators Association Incorporated (SOCOGESAFFIA).

1-4 Before the start of each season, the board members of the federation, officers of the different IAs, barangay (village-based political unit) officials, and government extension workers meet with the BARIS personnel to decide on the irrigation plan for the season. They decide which areas are to be irrigated, the start and cut-off of irrigation deliveries, and other management procedures. They also discuss problems and try to provide solutions during the meeting.

1-5 There is a monthly meeting of the federation board members with NIA personnel present to discuss problems and plan short-term strategies. Each IA has also a monthly meeting to serve as a forum for gathering feedback from farmers. Some of the IAs have a contract with NIA for maintenance of the laterals serving their area. Other laterals not contracted for maintenance by the farmers including the main canal are maintained by canal tenders paid by NIA as regular personnel.

1-6 Irrigation water supply is rotated among the sectors of the system. Each sector is provided with water for a specified number of days on a weekly schedule. This system of rotation is decided and fixed during the pre-seasonal farmers meeting. Thus, the schedule cannot be altered by the NIA management without consultation with farmers. NIA's role is to implement and enforce the rotation schedule. To prevent unscheduled water deliveries to any sector, unauthorized checks are removed and confiscated by NIA personnel during their daily rounds in the system and areas not scheduled for the season have their gates closed temporarily, sometimes with use of concrete to block the gates.

1-7 In areas where the farmers' associations are functional and have contracts for the maintenance of the lateral, the farmers' responsibility in water distribution starts at the lateral headgate. In areas where the association is not functional, the farmers' responsibility starts at the turnout. Thus, responsibilities of the NIA personnel are to enforce the rotation schedule as decided during the seasonal meetings and to implement alterations as decided during monthly meetings (see Interim Report for details on the minutes of the meetings).

1-8 Corn is irrigated at most twice every season when the rainfall amount is deemed insufficient. The method of irrigation is by "flushing" or basin irrigation. The NIA staff would only irrigate the corn fields upon the request of the farmers. Experience in this system indicate that with this method of irrigation it takes three days to irrigate a ha of corn. This is due to the moderate flow of water into the main farm ditch and the nearly flat topography of the corn fields. The sandy texture of the soil cannot accommodate large volume of flows in the main farm ditches. Only a few farmers in the dry season of 1984 requested for flushing irrigation from the NIA staff. These farmers were billed 60 percent equivalent irrigation fee based on rice (i.e. cash equivalent of 60 percent of 132 kg rough rice for the dry season).

1-9 The prevailing practice of farmers is to plant their corn crop adjacent to their rice plots. Due to lateral seepage, these corn plots do not require irrigation. The NIA staff in turn do not bill these farmers for corn as long as they pay their rice irrigation fee. However, strictly considering the water use, these corn fields are actually irrigated. For farmers not scheduled to receive water for rice irrigation, the rainfall would be deemed sufficient and only in cases of extreme drought will they request the NIA staff for "flushing" their corn fields as previously mentioned.

1-10 The IIMI study on irrigation management focused on the documentation of the operation and maintenance aspects of this system in relation to the identification of constraints to irrigated crop diversification.

1-11 A rainfall and evaporation station was established located at lateral DI (see irrigation map of BARIS). Staff gages were installed and calibrated at the headgate of the main canal, points along the main canal, and lateral headgates. Rainfall and evaporation data are presented in the results of the study at this site.

ANNEX II. MANI COMMUNAL IRRIGATION SYSTM (MCIS)

2-1 The MCIS is a communal irrigation system with a diversion dam located in Esperanza. Koronadal, South Cotabato. This system serves two villages, Mabini and Barrio 5 also of Koronadal. Its total service area is 700 ha but only 200-400 ha are served each season depending on water availability. It is managed by a communal irrigators association through its President, Mr. Santiago Billanes, and nine Board of Directors. The system is divided into five sectors each having a sector leader and other officials responsible for distributing water within their sector. There is a hired canal tender to oversee the distribution of water to the different sectors, and a hired gate keeper for the main diversion point responsible for closing and opening the gates of the dam.

2-2 The association meets before the start of the season to decide on the sectors to be irrigated, and the schedule of deliveries and cut-off dates for each sector. There are monthly meetings at the sector level to discuss problems. These problems art! then presented at the meetings of the Board of Directors usually called by the President to plan short-term strategies. Each sector is given a schedule to plant to cope with the limited water supply and the large amount required for land preparation (e.g. staggered planting dates by sector).

2-3 The canal tender patrols the canal daily to see that water is diverted to the scheduled sectors- In times of water shortage, rotation is practiced and each sector is given a fixed number of days per week. The canal tender adjusts the checks and clears the intake structures of debris to ensure that water flows to the scheduled sectors. Within each sector the farmers share the water through the supervision of the sector leader.

2-4 Corn is only irrigated when farmers formally request water from the association through the President. Farm ditches are maintained by the farmers. Laterals within each sector are maintained through group work whenever needed. The main canal is maintained also through group work and participating farmers are paid in terms of discounted irrigation fees, at the rate of P50/man-day.

2-5 IIMI's involvement in this system was based on the premise that farmers irrigate non-rice crops. However, the results show that only a few farmers irrigate their non-rice crop (mainly corn) and do so only in times of drought. There are also cases of irrigation through seepage from rice paddy fields. Lateral seepage is prevalent in the type of soil (sandy loam) in this service area and farmers deliberately take advantage of this.

2-6 This system also offers opportunity for studying the management of irrigation entirely by farmers. As part of IIMI's study on irrigation management, the system was instrumented for water flows on the main canal and laterals. A rainfall and evaporation station was also installed in the area.

I. Proposed Irrigation Water Management Scheme for a Rice-Based Cropping Pattern at NIA-ARIP PTDF No. 2, Lateral A extra[1]

Introduction

3-1 Proper planning is essential to the efficient operation of an irrigation system. The main. purpose of this preliminary study is to develop a water management scheme for the Pilot Testing and Demonstration Farm No. 2 (PTDF #2) for irrigated lowland rice in the wet season and irrigated corn in the dry season. This planting schedule is a prerequisite for the improvement of operstions even on a newly constructed irrigation system (e.g. PTDF No. 2), without necessitating major and costly revisions of already installed conveyance facilities and measuring structures.

Objectives

3-2 The three objectives of the study are:

1) To determine the irrigation water requirement of PTDF No. 2 particularly at Lateral A-Extra

2) To simulate a rice-based cropping pattern using the available rainfall record in the area and compute the crop irrigation needs

3) To recommend a cropping calendar as a basis of developing a method for water scheduling of irrigated non-rice crops

Determination of Irrigation Water Management Requirements

3-3 Technical description of lateral A-Extra. A detailed topographic map of the area served by Lateral A-extra was obtained (see blueprint original layout of PTDF #2). Other data included were the technical description of the area and irrigation facilities:

a) Length of lateral - 4.80 km
b) Design capacity - 0.391 cms

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1 This component study was done in collaboration with the research staff of USM headed by Engr. R. Sarmiento, Asst. Prof.

c) Number of double-gated turn-outs - 8.0
d) Total irrigable area - 348.2 ha
e) Breakdown of service area (ha)

i. RA-1 = 43	v. RA-5 = 100
ii. RA-2 = 35.2	vi. SPL-1 = 27
iii. RA-3 = 32	vii. SPL-2 = 13
iv. RA-4 = 47	viii. SPL-3 = 21

f) Inventory of discharge measuring devices
   i. One (1) concrete Parshall Flume = 122 cm throat width (Non-Functional)
   ii. Double-gated turn-outs = 8.0 units

g) Soil type = Banga-sandy-clay loam
h) Average water table depth = 128 cm
i) Average slope = 0.2%

3-4 Analysis of hydrometeorological data.

a) Rainfall

An eighteen (18) year record of daily rainfall and evaporation were obtained from the nearby station of Norala, South Cotnbato. Total rainfall was analyzed using the Incomplete Gamma distribution function. The values of rainfall with 20 percent, 50 percent and 80 percent cumulative probabilities are shown in Fig. III.1 of :he main report.

b) Pan Evaporation and Potential Evapotranspiration

Data on the average monthly total pan evaporation (Ep) data were obtained wherein the potential evapotranspiration was assumed to equal to this value. A 60% distribution efficiency from lateral headgate to field is assumed. Since the lateral is lined, negligible water loss is expected in but since the area is sandy it is expected that losses in farm ditches will be high. The recommended revision in farm ditch density and number of turnouts to reduce lengthy main farm ditches is expected to lower this loss but still we assumed a 60% efficiency because of the very porous soil texture in the area. If farm ditches are constructed with haul-borrow materials of appropriate texture this assumed efficiency could be higher. Though the design flow of Lateral A-Extra is 391 lps, there is enough freeboard to accommodate a higher flow.

Land Soaking Requirement (Lowland rice)

3-5 The following data were used for computing the land soaking requirement:

Seepage and Percolation Rate (S&P) = 10 mm/day
Residual soil moisture (M) = 10%
Soil Moisture at saturation (Ms) = 30%
Evapotranspiration (Eo) = 4 mm/day
Apparent Specific gravity (As) = 1.50
Soil depth to be saturated (Ds) = 300 mm
Saturation Requirement (SR) = [(Ms - M)*(As)*(Ds)]/100
= [(30-10) (1.5) (300)]/100
= 90 mm

Land Soaking Requirement (LSR) = SR + 7 (Eo) + 7 (S&P)
(1 week period)
=90 + 7 (4) + 7 (10)
-90 + 28 + 70
=188 mm/wk

Normal Irrigation Requirement (NIR) = 7 (Eo) + 7 (S&P)
= 98 mm/wk

3-6 It can be seen from actual data that pan evaporation does not vary much from a range value of 3-6 mm/day. The five-year mean weekly pan evaporation data were used as values for evapotranspiration (ET).

Results

3-7 Probable Rainfall Analysis. There was 5-year data for pan evaporation available for the area while there was 18 year available rainfall data which was used in the simulation. For other years without pan evaporation data the 5-year mean was used. The weekly rainfall probability distribution was analyzed using the incomplete gamma function and the 20 percent, 50 percent and 80 percent probable rainfall was computed.

3-8 Rainfall is minimal in the period February to May as shown by the graph of the probable rainfall (Fig. III.1). It can also be seen from this figure that rainfall is not sufficient to supply evaporation from January to April because the mean evaporation for this period is 40 mm/wk. This shows that irrigation is needed for a dry season diversified crop.

Cropping Simulation

3-9 Assumptions:

Simulation 1:

Wet Season.

1) Start of season is first week of May.
2) Land Soaking is staggered to 4 weeks because of limitation on canal capacity.
3) Three weeks land preparation duration to coincide with 21 days of seedling growth for transplanted rice.
4) 120 day variety rice is used.
5) 60% overall efflciency is assumed.

Dry Season.

1) Start of season is 4 weeks after harvest of rice.
2) 105 day maturity corn.
3) Irrigation is to be done when the available soil moisture for the upper 60 cm soil depth is below 50%.
4) 40% overall efflciency.

Simulation 2:

All assumptions for simulation 1 hold except that the dry season starts immediately after harvest of the rice crop.

3-10 The flow chart for the simulation is presented in Fig. A.1.

3-11 Results of the simulation shows that the seasonal water requirement for the rice crop would be 1,700 to 2,300 mm. After considering rainfall the seasonal irrigation diversion requirement ranges from 900 to 1800 mm with an average of 1360 mm. On an average year the daily requirement will not exceed the 2 lps/ha design of the ARIP System (Tables 1-3).

3-12 For the corn crop, seasonal irrigation diversion requirement simulated for 18 years ranged from 70 mm to 250 mm for simulation 1 while ranging from 50 to 200 mm for simulation 2. It is less for simulation 2 because of earlier planting hence higher rainfall probability during crop growth.

3-13 Table 4 shows the result of the simulation using the weekly probable rainfall values at 20 percent, 50 percent and 80 percent. For the 20 percent probable rainfall, the first simulation results in six irrigations for the dry season corn crop, done every two weeks (Fig. A2). However an earlier planting for the second simulation results in four irrigations done once every three weeks because of rainfall availability (Fig. A3). The weekly irrigation needs of the first crop of rice will be more than the design value for ARIP averaging 2.5 lps/ha.

3-14 For the 50 percent weekly probable rainfall the average irrigation needs for the wet season rice crop will be 1.9 lps/ha. The dry season corn crop will need three irrigations for late planting (simulation 1-Fig. A.4) and two irrigations for late planting (simulation 2-Fig. A.5).

3-15 For 80 percent weekly probable rainfall the average irrigation needs of the wet season rice crop will be 1.1 lps/ha. The dry season corn crop will need two irrigations for late planting (Fig. A.6) and one irrigation for early planting (Fig. A. 7).

3-16 The simulations show that irrigation will be needed once every two weeks if there is no rainfall for the dry season corn crop in order to maintain the soil moisture above stress levels. They further show that dry season diversified crops grown in the areas served by ARIP need irrigation for optimum production.

Recommended Cropping Calendar

3-17 The proposed cropping schedule for wet season rice is shown in Table 4. It is proposed that irrigation delivery for this crop should be in the week May 7-13 or the first or second week of May as it is indicated in the probability analysis of rainfall on the onset of the rainy season. It is assumed that there will be a time lag from land soaking to transplanting of about four weeks for seed-bed raising for transplanted rice.

3-18 The irrigation water requirement computation is shown in Table 5. It is assumed that seepage and percolation is 10 mm/day from the data gathered at PTDF #2, land saturation requirement is 90 mm assuming a saturated depth of 30 cm, soil moisture saturation of 30% and 10% residual soil moisture.

3-19 The assumed 10 mm/day seepage and percolation rate was estimated for two paddy sites at PTDF #2. Sample soil borings in area revealed a layer which is impenetrable by soil auger. It is likely that this layer exists throughout the entire service area at a depth ranging from 0.5 m to 1.5 m. This layer maybe semi-permeable, thus reducing the value of seepage and percolation. It seems to follow the natural slope of the land wherein it is steeper at some areas and flatter at other areas. It is shallowest in the areas near the highway and deepest near the Allah River. It has a low permeability as evidenced by water ponded near the highway where some ricelands were developed.

3-20 Another significance of this layer is that during the dry season, the corn crop will be solely dependent on surface water supply either through rainfall or irrigation. This will be due to the deeper water table below this impenetrable layer.

3-21 In the above proposed cropping schedules the proposed re-design of on-farm irrigation facilities for the lateral was considered. Irrigation delivery starts at the end of the lateral (i.e. the tail enders receive irrigation first and prepare their land first). The turnouts are grouped to satisfy the required area to be prepared each week. The groupings for the dry season are presented in Tsbles **6** to **13.**

3-22 To conceptualize the actual Irrigation delivery schedule for the whole lateral, the four groups of turnouts are considered separately. Since the lateral is lined, conveyance loss is assumed to be negligible. The farm ditches are unlined **so** the distribution and conveyance efficiency within the turnout area is assumed to be **75%.** If the field application efficiency is assumed to be 60%, the overall efficiency is **40% (0.75x0.6x100%).** If the main farm ditches are lined, the conveyance and distribution can be considered negligible; thus the over-all efficiency can be assumed to be **60%.**

3-23 Through **soil** moisturr water balance the time to irrigate each group and the time to irrigate each turnout group was obtained assuming irrigation at ***50%*** available soil moisture. Assuming **40%** efficiency, the irrigation needs for each turnout group **are** presented in Tables **8, 10, 12, 6** 14. Since the main farm ditches are unltned, their capacfty was limited to 75 lps. Irrigation time was limited to **10** hrs/day because supervision in field irrigation is needed. There are times where the irrigation needs of the turnout group cannot be attained because of the flow limitation as in Tables 9, **11 6 13.** Thus, irrigation has to be delivered in more than one week. There are periods when more than one turnout group require water in the same week. The capacity of the lateral **(390** lps) limits the flow available at each group hence the time to Lrrigate is further extended to adapt to this limitation. The final irrigation delivery considering these limitations are presented in Tables **7, 8,** 11 **& 13.**

3-24 Because the main farm ditches are lined, their capacity can be adjusted to that of the turnouts **(150** lps). The efficiency can also be assumed to be ***60%.*** Considering all limitations, the irrigation schedules are presented in Tables 14 to **17.**

3-25 The summary for both irrigation schedules is presented in Table **18.** For **40%** efffciency and **75** lps discharge limitation for each main farm ditch, Lateral A extra would operate **for 45** days for the whole dry season. with an average flow of **248** lps (10 hrs operation per day). The maximum is **383** lps and the minimum is **208** lps. **If** the main farm ditches are lined to increase efficiency and capacity, then Lateral A extra will only operate for **18** days for the whole dry season with average flow of **341** lps (10 hrs per day operation). The maximum is **331** lps and the minimum is **343** lps.

3-26 This analysis correlates with the simulation results, using the 50% available rainfall. The corn crop **for** the dry season, when planting is done from early November to middle of December, will only need two to three irrigations.

3-27 It is likely that this proposed water management scheme cannot be implemented immediately due *to* the land development required in order that irrigated lowland rice cultivation can be adopted in the wet season. Likewise, land development for irrigated corn cultivation for the dry season has to be undertaken due to the undulating terrain in most parts of the service area.

Design Considerations for On-farm Facilities

3-28 The design of on-farm facilities should consider the demand of diversified crops because, even if the total seasonal volume needed is less than that required for rice, such volume should be delivered in a shorter length of time resulting in a higher discharge rate. If irrigation is to be applied at 50% available **soil** moisture, the actual irrigation required could be computed as:

$$IR\ (mm) = \frac{0.5\ (FC - PWP)}{100} \times S.G. \times RSD$$

where:
- FC = field capacity, %
- PWP = permanent wilting point, %
- RSD = root zone depth, mm
- S.G. = Specific gravity of the soil
- IR = required irrigation water to replenish soil moisture to field capacity

Using the data for **PTDF** No. 2 and a root zone depth of 60 cm, IR will be 67.5 mm. If field application efficiency of 60% is assumed, the actual required depth will be 112.5 mm. If the turnout is irrigated for five days the daily demand will be 22.5 mm. If 10 hours of operation is assumed, the design capacities of on-farm facilities will be 6.25 lps/ha. If 7-day operation per week at 10 hrs/day is assumed, the design capacity would be less at 4.5 lps/ha.

3-29 On the main system facilities (main canals, laterals, etc.), the design capacity will be less. Even if there is no rainfall, diversified crops like corn will only need irrigation once every two weeks as shown by simulation. Hence, every week only 1/2 of the service area will be actually irrigated. The main system capacity will be only 1/2 of the turnout design capacity. For 7-day operation per week, the lateral design capacity of Lateral A-extra will be 623 lps (4.5 x 139 has). This is 60% more than the designed capacity of 390 lps. The above design capacity will be needed if there is a severe drought, which will be the basis of design to avoid crop failure.

3-30 ARIP is designed for 2 lps/ha capacity. This is still less than the required design capacity if the whole area were planted to diversified crops in the dry season. As cited above, the main system design capacity will be 2.25 lps/ha, 1/2 of the turnout design capacity of *4.5* lps/ha. For total system crop diversification the design capacity should be increased by 12.5%. However, ARIP is not designed for total crop diversification, but only parts of it with other areas planted to lowland rice in the dry season. Hence, only the laterals to be programmed for total crop diversification in the dry season should be evaluated and redesigned if they have the capacity to meet the water demand of diversified crops. Moreover, since diversified crops do not need continuous irrigation. it is possible to program the irrigation deliveries to cope with the design limitations as shown (Table 18) €or the *40%* efficiency assumption by increasing the period of operation.

3-31 This capacity may not actually be needed in most years as shown in the recommended cropping pattern for Lateral A-Extra. Analyzing the resulting irrigation needs for the lateral and considering the actual capacity, the needs of the wet season rice crop can be accommodated. Calibrations done on the lateral headgate shows that it can deliver up to 500 lps.

3-32 For the corn crop, the capacity of 390 lps is not exceeded as the maximum discharge required is only 383 lps (Table 18). For rice, the irrigation demand is continuous at a smaller volume rate per ha, while for dry season corn the demand is intermittent with a larger volume rate. This is not readily seen in the accompanying tables. The highest irrigation demand occurs in week 37 for wet season rice at *497* lps (Table *5)*. The irrigated area for that week is *277* ha (Table 4). The rate is 1.8 lps/ha. For corn the highest lateral demand rate is 383 lps occurring in week *5* (Table 18). The irrigated area is 153 ha (Table *6* & 8). The resulting irrigation rate is 2.5 lps/ha, but in terms of the whole lateral service area of *277* ha, it is only *1.4* lps/ha.

3-33 The resulting highest turnout rate occurs in week *4* for the turnouts **5**, *6*, and *7* at 343 lps irrigating *74* ha (Table **8** & 15). The equivalent rate per turnout will be *4.6* lps/ha. This shows that to be able to deliver the needed irrigation water for the diversified crop in the least possible time to avoid crop stress, the on-farm facilities should be designed at a higher capacity. The main farm ditches should be lined to lower the needed capacity to account for conveyance losses.

3-34 It is recommended thnt measuring structures at turnouts be installed to prevent excessive flow that may erode ditches and cause water logging. This will ensure that only the right amount of water is diverted per turnout. There is also a need to inform the farmers on the proper irrigation methods and on the use **of** the facilities to ensure effective operation.

II. Proposed design of Farm Level Irrigation Facilities for Lateral A-Extra, at PTDF #2[2]

Introduction

3-35 Lateral A-Extra, of ARIP which is the site of the PTDF #2 was basically designed for diversified cropping especially during the dry season. This lateral was selected as the site for PTDF #2 to develop experience useful in operating ARIP. The whole ARIP was designed for large areas devoted to diversified cropping. The main purpose of this study is to analyze the on-farm facilities design of the lateral, considering the above criteria of irrigating diversified crops and provide suggestions for the redesign of the on-farm facilities for efficient management of the lateral. These objectives were implicit in the terms of reference in the T.A. PHI 654, whereby assistance to NIA in developing strategies for irrigating diversified crops will be provided by IIMI.

Methodology

3-36 Original design of Lateral A-Extra, including map layouts and location of turnouts were obtained from the design section of ARIP. Actual field verifications of the area were done to observe physical conditions of the irrigation structures. Observations were also made during trial operations of the lateral in the wet season of 1985. A contour map of the area was also obtained. All these data and observations were used in the analysis and development of recommendations for re-design of the on-farm facilities (Fig. I.1).

Results and Recommendations

3-37 There are eight turnouts constructed to serve the whole area. All these turnouts were designed as double gated (constant head orifice) with designed capacities of about 75 lps at 20 cm head. These turnouts are shown in the attached layout map (Fig. 1.2) of the proposed turnout and farm ditch locations, and summarized in Table 20.

3-38 One major consideration in the re-design was to locate the supplementary farm ditches (SFD) and main farm ditches (MFD) on property line boundaries for more accessibility of water per farmer and to facilitate easier construction of interral farm ditches which are necessary for irrigating diversified crops.

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2 This report is the second part of the study on the proposed water management scheme at PTDF #2 and was jointly undertaken by the IIMI and USM staff.

3-39 The first turnout of the lateral is at RA SPL 1. It can be noted from the map that it can not serve the area above the turnout and below the creek. From field observations, farmers in this area tried to irrigate the area above and hence excessive checking was done at STA 1 + 480 to force water flow upstream. The recommendation is to relocate the turnout about 220 meters upstream. The resulting farm ditch layout is indicated in the map and ditch lengths are shown in Table 20. There is a need for a checking structure for the relocated turnout.

The specifications will be:

Highest elevation to be supplied	- 183.5	meters
Assumed Water depth at farm ditch	- 0.2	meter
Needed Hydraulic head	- 0.1	meter
Designed Water surface elevation at lateral (STA 1+260)	- 183.6	meters
Head to be produced by check	- 0.2	meters
(A weir check may serve the purpose.)		

3-40 The second turnout is at RA 1. It can be noted from the map that the first SFD of this turnout is flowing uphill hence the recommended modifications are shown in the modified layout map and summarized in Table 20. The third turnout is at RA 2 and from the original layout map, it appears that the proposed layout of farm ditches may not be enough for diversified crop irrigation specially at the upstream portion hence the proposed modification.

3-41 The fourth turnout for RA 3 shows the main farm ditch to go from a lower to a higher contour, so it is necessary to relocate the MFD at a higher elevation. To cover the whole area would then require a long farm ditch about 1.2 km long; hence it is proposed to have two turnout for this area. The new turnout will be located at STA 3 + 605 or turnout number 6 in Table 20. The fifth turnout which is located at STA 2 + 805 left is serving RA 4 was considered as good hence it is recommended to retain the original design.

3-42 The turnout at STA 3 + 605 has also a very long MFD hence is also recommended that there should be two turnouts. The additional turnout should be located at STA 4 + 425. The turnout at STA 3 + 920 is at elevation 168.5 and the MFD as shown in Fig. 2 is to pass a contour line of 171.5 which is three meters higher. The recommendation is to relocate the turnout at STA 4 + 245. At the end check the area to be served is still 100 hectares which is considered too large especially for irrigation of diversified crops. It was also noted in the trial irrigation run that farmers can not maintain a main farm ditch because of the highly erosive flow. It is therefore recommended to extend the lateral for another 800 meters with cement lining and divide the area of RA 5 into three. The first two blocks will be served by the turnout at STA 4 + 245. The next three blocks will be irrigated by a new turnout at STA 4 + 980. The remaining portion will be served by the end check turnout.

3-43 It is suggested that no turnout will serve less than 15 ha but not more than 50 ha. The recommended supplementary farm ditches are not enough for diversified crop irrigation and there is a need for internal farm ditches. It maybe adequate for lowland rice irrigation as paddy to paddy flow could be used but such is not adaptable for upland crop irrigation. Hence there is a need for internal farm ditches.

3-44 There may also be a need for some landleveling especially at the upper half of the service area of the lateral which has a very undulating terrain in order to facilitate easier water distribution.

3-45 Before the final construction of the recommended farm ditches there is also a need to look out for drainability of the areas as upland crops are very sensitive to water logging. It is also recommended that the proposed new turnouts be constructed as single gated ones for economy.

3-46 The proposed revisions in farm ditch layouts were based on a contour map of 0.5 meter interval and not on a 0.2 meter interval which is desirable for such. Farmers should participate in locating and constructing farm ditches. Involving farmers will ensure effective use of these ditches. It is suggested that the sizes and construction materials for the main farm ditches follow design specifications developed by NIA.

Table 1. Summary of crop simulation for an irrigated rice-corn cropping pattern, South Cotabato, 1968 to 1986.

CROP	First Simulation						Second Simulation					
	SS	ES	TR	TEV	TWR	IDR	SS	ES	TR	TEV	TWR	IDR
						1968-69						
Rice	20	43	1181	615	2393	1364	20	43	1181	615	2393	1364
Corn	47	16	301	673	562	171	44	13	277	554	485	163
						1969-70						
Rice	19	42	1654	625	2406	972	19	42	1654	625	2406	972
Corn	47	16	563	668	559	102	44	13	722	622	513	69
						1970-71						
Rice	19	42	1311	625	2499	1405	19	42	1311	625	2499	1405
Corn	47	16	695	673	562	73	44	13	524	627	517	72
						1971-72						
Rice	19	42	1500	597	2499	1163	19	42	1500	597	2499	1163
Corn	47	16	707	673	562	91	44	13	784	627	517	54
						1972-73						
Rice	19	42	1185	597	2499	1352	19	42	1185	597	2499	1352
Corn	47	16	175	673	562	227	44	13	174	627	517	180
						1973-74						
Rice	19	42	1611	597	2499	967	19	42	1611	597	2499	967
Corn	47	16	473	673	562	81	44	13	565	627	517	52
						1914-75						
Rice	19	42	1554	597	2499	1010	19	42	1554	597	2499	1010
Corn	47	16	560	673	562	145	44	13	579	627	517	77
						1975-76						
Rice	19	42	1668	589	2491	1119	19	42	1668	589	2491	1119
Corn	47	16	632	613	562	87	44	13	699	721	530	30
						1976-77						
Rice	19	42	1165	597	2499	1360	19	42	1165	597	2499	1360
Corn	47	16	409	673	562	93	44	13	405	627	517	71

SS - Start of the Season (Week of the Year)
ES - End of the Season (Week of the Year)
TR - Total Rainfall for the Crop Season, mm
TEV- Total Pan Evaporation for the Crop Season, mm
WR- Total Crop Water Requirement for the Crop Season, mm
IDR- Total Irrigation Diversion Requirement for the Crop Season, mm
Second Simulation assumption is Land Preparation for the Corn Crop start just after harvest of the rice crop
First Simulation assumption is Land Preparation for the Corn Crop start 4 weeks after the harvest of the rice crop.

Table 2. Summary of crop simulation for an irrigated rice-corn cropping pattern, South Cotabato, 1968 to 1969

CROP	First Simulation						Second Simulation					
	SS	ES	TR	TEV	TWR	IDR	SS	ES	TR	TEV	TWR	IDR
						1977-78						
Rice	19	42	1541	597	2499	1107	19	42	1541	597	2499	1107
Corn	47	16	283	673	562	200	44	13	360	627	517	165
						1978-79						
Rice	19	42	1682	597	2499	1191	19	42	1682	597	2499	1191
Corn	47	16	395	673	562	155	44	13	395	673	485	132
						1979-80						
Rice	19	42	977	597	2499	1605	19	42	977	597	2499	1605
Corn	47	16	444	673	562	78	44	13	778	627	517	46
						1980-81						
Rice	19	42	1004	618	2520	1627	19	42	1004	618	2520	1627
Corn	47	16	512	846	700	225	44	13	564	772	635	153
						1981-82						
Rice	19	42	1010	822	2724	1805	19	42	1010	822	2724	1805
Corn	47	16	515	751	623	114	44	13	655	726	598	103
						1982-83						
Rice	19	42	741	631	2533	1842	19	42	741	631	2533	1842
Corn	47	16	190	742	639	231	44	13	263	640	535	183
						1983-84						
Rice	19	42	1586	649	2551	1289	19	42	1586	649	2551	289
Corn	47	16	448	510	427	106	44	13	507	502	410	70
						1984-85						
Rice	19	42	733	570	2472	1760	19	42	733	570	2472	760
Corn	47	16	372	575	469	153	44	13	352	570	465	130
						1985-86						
Rice	19	42	833	488	2390	1589	19	42	833	488	2390	1589
Corn	47	16	549	598	486	78	44	13	646	557	457	43

SS - Start of the Season (Week of the Year)
ES - End of Season (Week of the Year)
TR - Total Rainfall for the Crop Season, mm
TEV– Total Pan Evaporation for the Crop Season, mm
WR– Total Crop Water Requirement for the Crop Season, mm
IDR– Total Irrigation Diversion Requirement for the Crop Season, mm
Second Simulation assumption is Land Preparation for the Corn Crop start just after harvest of the rice crop
First Simulation assumption is Land Preparation for the Corn Crop start 4 weeks after the harvest of the rice crop

Table 3. Summary of crop simulation for an irrigated rice-corn cropping pattern, South Cotabato, 1969 to 1986.

CROP	First Simulation						Second Simulation					
	SS	ES	TR	TEV	TWR	IDR	SS	ES	TR	TEV	TWR	IDR
				20% Probable Rainfall								
Rice	20	43	550	717	2619	2069	20	43	550	717	2619	2069
Corn	47	16	100	633	534	228	44	13	150	595	493	165
				50% Probable Rainfall								
Rice	19	42	1051	717	2619	1568	19	42	1051	717	2619	1568
Corn	47	16	319	633	534	107	44	13	398	595	493	93
				80% Probable Rainfall								
Rice	19	42	1766	717	2619	856	19	42	1766	717	2619	856
Corn	47	16	571	633	534	82	44	13	697	595	493	44

SS - Start of the Season (Week of the Year)
ES - End of Season (Week of the Year)
TR - Total Rainfall for the Crop Season. mm
TEV- Total Pan Evaporation for the Crop Season, mm
WR- Total Crop Water Requirement for the Crop Season, mm
IDR- Total Irrigation Diversion Requirement for the Crop Season, mm
Second Simulation assumption is Land Preparation for the Corn Crop start just after harvest of the rice crop
First Simulation assumption is Land Preparation for the Corn Crop start 4 weeks after the harvest of the rice crop.

Table 4. Proposed Progress of Farming Activities for the Lateral A-Extra ARIP Dam # 1, Surallah, South Cotabato, Wet Season, Rice Crop.

Wk. No.	Date	ADLS (has.)	ADLP (has.)	AUNI (has.)	AUTD (has.)
19	May 7-13	100			
20	14-20	85	100		
21	21-27	70	185		
22	28-Jun 3	22	255		
23	Jun 4-10		177	100	
24	11-17		92	185	
25	18-24		22	255	
26	25-Jul 1			277	
27	2-8			277	
28	9-15			277	
29	16-22			277	
30	23-29			277	
31	30-Aug 5			277	
32	6-12			277	
33	13-19			277	
34	20-26			277	
35	27-Sep 2			277	
36	3-9			277	
37	10-16			277	
38	17-23			277	
39	24-30			277	
40	Oct 1-7			177	100
41	8-14			92	185
42	15-21			22	255
43	22-28				277
44	29-Nov 4				277

AULS - Area Under Land Soaking
AULP - Area Under Land Preparation
AUNI - Area Under Normal Irrigation
AUTD - Area Under Terminal Drainage

Table 5. Irrigation Water Requirement Computation Lateral A-Extra, ARIP Dam# 1, Surallah, South Cotabato. Wet Season Rice Crop.

Wk. No.	Date	Crop Water Reqm't w/O Rain lps	Crop Water Reqm't w/ Rain lps	R'fall mm/wk.	IDR lps**
19	May 7–13	311	253	35	422
20	14–20	426	276	49	460
21	21–27	517	323	46	538
22	28–Jun 3	482	211	59	352
23	Jun 4–10	449	220	50	367
24	11–17	449	206	53	343
25	18–24	449	174	60	290
26	25–Jul 1	449	215	51	358
27	2–8	449	256	42	427
28	9–15	449	261	41	435
29	16–22	449	261	41	435
30	23–29	449	215	51	358
31	30–Aug 5	449	211	52	352
32	6–12	449	261	41	435
33	13–19	449	270	39	450
34	20–26	449	224	49	373
35	27–Sep 2	449	229	48	382
36	3–9	449	261	41	435
37	10–16	449	298	33	497
38	17–23	449	243	45	405
39	24–30	449	266	40	443
40	Oct 1–7	287	181	36	302
41	8–14	149	96	35	160
42	15–21	36	21	40	35
43	22–28	0	0	42	0
44	29–Nov 4	0	0	32	0

IDR – Irrigation Diversion Requirement

** Assuming 60% Efficiency

Table 6. Proposed Progress of Farming Activities for the turnouts 8, 9, 10 6 11, Lateral A–Extra, ARIP Dam# 1, Surallah, South Cotabato, Dry Season Corn Crop.

Wk. No.	Date	AULP (has.)	PA (has.)	VS (has.)	RS (has.)	MS (has.)
42	Oct 15–21	79				
43	22–28	79				
44	29-Nov 4		79			
45	5–11			79		
46	12–18			79		
47	19–25			79		
48	26–Dec 2			79		
49	Dec 3–9			79		
50	10–16			79		
51	17–23				79	
52	24–31				79	
1	Jan 1–7				79	
2	8–14				79	
3	15–21					79
4	22–28					79
5	29–Feb4					79
6	Feb 5–11					79
7	11–18					
8	19–25					
9	26-Mar4					
10	Mar 5–11					
11	12–18					
12	19–25					

AULP - Area Under Land Preparation
PA - Planted Area
VS - Area Under Vegetative Stage
RS - Area Under Reproductive Stage
MS - Area Under Maturity Stage

Table 7. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 8, 9, 10, & 11, Dry Season Corn Crop

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21	15	35	27			
43	22-28	15	40	29			
44	29-Nov 4	15	42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	19-25	15	22	26			
48	26-Dec 2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	12	19	24			
52	24-31	11	18	29	7400	88	7.0
1	Jan 1-7	15	27	25			
2	8-14	15	11	28			
3	15-21	13	11	27			
4	22-28	11	24	23			
5	29-Feb 4	11	9	25	71100	282	7.0
6	Feb 5-11	11	10	24			
7	11-18		19	32			
8	19-25		17	27			
9	26-Mar4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 40% combined field, conveyance and distribution efficiency.

Table 8. Proposed Progress of Farming Activities for the the Lateral A–Extra ARIP Dam # 1, Surallah, South Cotabato, Turnouts 5, 6 & 7, Dry Season Corn Crop.

Wk. No.	Date	LP (has.)	PA (has.)	VS (has.)	RS (has.)	MS (has.)
42	Oct 15–21					
43	22–28	74				
44	29-Nov 4	74				
45	5–11		74			
46	12–18			74		
47	Nov 19–25			74		
48	26–Dec 2			74		
49	Dec 3–9			74		
50	10–16			74		
51	17–23			74		
52	24–31				74	
1	Jan 1–7				74	
2	8–14				74	
3	15–21				74	
4	22–28					74
5	29–Feb 4					14
6	Feb 5–11					74
7	11–18					74
8	19–25					
9	26–Mar 4					
10	Mar 5–11					
11	12–18					
12	19–25					

AULP - Area Under Land Preparation
PA - Planted Area
VS - Area Under Vegetative Stage
RS - Area Under Reproductive Stage
MS - Area Under Maturity Stage

Table 9. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 5, 6 & 7, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15–21		35	27			
43	22–28	15	40	29			
44	29-Nov 4	15	42	33			
45	5–11	15	32	25			
46	12–18	15	26	24			
47	Nov19-25	15	22	26			
48	26-Dec2	14	34	28			
49	Dec 3–9	15	25	22			
50	10–16	15	21	33			
51	17–23	11	19	24	30000	119	7.0
52	24–31	10	18	29	25500	101	7.0
1	Jan 1–7	7	27	25			
2	8–14	15	11	28			
3	15–21	12	11	27			
4	22–28	10	24	23	30000	208	4.0
5	29–Feb4	15	9	25	25500	101	7.0
6	Feb 5–11	13	10	24			
7	11–18	11	19	32			
8	19–25		17	27			
9	26–Mar4		6	29			
10	Mar 5–11		9	33			
11	12–18		7	40			
12	19–25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 40% combined field, conveyance and distribution efficiency.

Table 10. Proposed Progress of Farming Activities for the Lateral A–Extra ARIP Dam # 1, Surallah, South Cotabato, Turnouts 3 & 4, Dry Season Corn Crop.

Wk. No.	Date	AULS (has.)	PA (has.)	VS (has.)	RS (has.)	MS (has.)
42	Oct 15–21					
43	22–28					
44	29–Nov 4	70				
45	5–11	70				
46	12–18		70			
47	Nov 19–25			70		
48	26–Dec2			70		
49	Dec 3–9			70		
50	10–16			70		
51	17–23			70		
52	24–31			70		
1	Jan 1–7				70	
2	8–14				70	
3	15–21				70	
4	22–28				70	
5	29–Feb4					70
6	Feb 5–11					70
7	11–18					70
8	19–25					
9	26–Mar4					
10	Mar 5–11					
11 .	12–18					
12	19–25					

AULP - Area Under Land Preparation
PA - Planted Area
VS - Area Under Vegetative Stage
RS - Area Under Reproductive Stage
MS - Area Under Maturity Stage

Table 11. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 3 & 4, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21		35	27			
43	22-28		40	29			
44	29-Nov 4	15	42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	Nov 19-25	15	22	26			
48	26-Dec 2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	12	19	24	31500	125	7.0
52	24-31	15	18	29			
1	Jan 1-7	13	27	25			
2	8-14	13	11	28	33000	131	7.0
3	15-21	11	11	27	30000	139	6.0
4	22-28	15	24	23			
5	29-Feb 4	15	9	25			
6	Feb 5-11	13	10	24			
7	11-18	11	19	32			
8	19-25		17	27			
9	26-Mar 4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 40% combined field, conveyance and distribution efficiency

Table 12. Proposed Progress of Farming Activities for the Lateral A-Extra ARIP Dam # 1, Surallah, South Cotabato, Turnouts 1 & 2, Dry Season Corn Crop.

Wk. No.	Date	AULP (has.)	PA (has.)	VS (has.)	RS (has.)	MS (has.)
42	Oct 15-21					
43	22-28					
44	29-Nov 4					
45	5-11					
46	12-18	54				
47	Nov 19-25					
48	26-Dec 2		54			
49	Dec 3-9			54		
50	10-16			54		
51	17-23			54		
52	24-31			54		
1	Jan 1-7			54		
2	8-14			54		
3	15-21				54	
4	22-28				54	
5	29-Feb 4				54	
6	Feb 5-11				54	
7	11-18					54
8	19-25					54
9	26-Mar 4					
10	Mar 5-11					
11	12-18					
12	19-25					

AULP - Area Under Land Preparation
PA - Planted Area
VS - Area Under Vegetative Stage
RS - Area Under Reproductive Stage
MS - Area Under Maturity Stage

Table 13. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A–Extra., Surallah, South Cotabato, Turnouts 2 6 1, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15–21		35	27			
43	22–28		40	29			
44	29–Nov 4		42	33			
45	5–11	15	32	25			
46	12–18	15	26	24			
47	Nov 19–25	15	22	26			
48	26–Dec 2	14	34	28			
49	Dec 3–9	15	25	22			
50	10–16	15	21	33			
51	17–23	11	19	24	24300	96	7.0
52	24–31	15	18	29			
1	Jan 1–7	13	27	25			
2	8–14	13	11	28	28600	113	7.0
3	15–21	11	11	27	20000	93	6.0
4	22–28	15	24	23			
5	29–Feb 4	15	9	25			
6	Feb 5–11	13	10	24			
7	11–18	11	19	32			
a	19–25	10	17	27			
9	26–Mar 4		6	29			
10	Mar 5–11		9	33			
11	12–18		7	40			
12	19–25		11	40			

MC – Soil Moisture Content at beginning of week, % by weight.
RF – Rainfall
ET – Evapotranspiration
IR – Irrigation Requirement assuming 40% combined field, conveyance

Table 14. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 8, 9, 10, & 11, Dry Season Corn Crop

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21	15	35	27			
43	22-28	15	40	29			
44	29-Nov 4	15	42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	19-25	15	22	26			
48	26-Dec 2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	12	19	24			
52	24-31	11	18	29	31600	176	5.0
1	Jan 1-7	15	27	25			
2	8-14	15	11	28			
3	15-21	13	11	27			
4	22-28	11	24	23			
5	29-Feb 4	11	9	25	31600	293	3.0
6	Feb 5-11	11	10	24			
7	11-18		19	32			
8	19-25		17	27			
9	26-Mar 4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 60% combined field, conveyance and distribution efficiency.

Table 15. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 5, 6 & 7, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21		35	27			
43	22-28	15	40	29			
44	29-Nov 4	15	42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	Nov 19-25	15	22	26			
48	26-Dec2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	11	19	24			
52	24-31	10	18	29	37000	206	5.0
1	Jan 1-7	7	27	25			
2	8-14	15	11	28			
3	15-21	12	11	27			
4	22-28	10	24	23	37000	343	3.0
5	29-Feb4	15	9	25			
6	Feb 5-11	13	10	24			
7	11-18	11	19	32			
8	19-25		17	27			
9	26-Mar4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 60% combined field, conveyance and distribution efficiency.

Table 16. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 3 6 4, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21		35	27			
43	22-28		40	29			
44	29-Nov 4	15	42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	Nov 19-25	15	22	26			
48	26-Dec 2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	12	19	24	21000	194	3.0
52	24-31	15	18	29			
1	Jan 1-7	13	27	25			
2	8-14	13	11	28			
3	15-21	11	11	27	28000	194	4.0
4	22-28	15	24	23			
5	29-Feb 4	15	9	25			
6	Feb 5-11	13	10	24			
7	11-18	11	19	32			
8	19-25		17	27			
9	26-Mar 4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 60% combined field, conveyance and distribution efficiency.

Table 17. Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A-Extra, Surallah, South Cotabato, Turnouts 2 & 1, Dry Season Corn Crop.

Wk. No.	Date	MC (%)	RF (mm/wk)	ET (mm/wk)	IR (cu. m.)	IR (lps)	Time (days)
42	Oct 15-21		35	27			
43	22-28		40	29			
44	29-Nov 4		42	33			
45	5-11	15	32	25			
46	12-18	15	26	24			
47	Nov 19-25	15	22	26			
48	26-Dec 2	14	34	28			
49	Dec 3-9	15	25	22			
50	10-16	15	21	33			
51	17-23	12	19	24	16200	150	3.0
52	24-31	15	18	29			
1	Jan 1-7	13	27	25			
2	8-14	13	11	28			
3	15-21	11	11	27	21600	150	4.0
4	22-28	15	24	23			
5	29-Feb 4	15	9	25			
6	Feb 5-11	13	10	24			
7	11-18	11	19	32			
8	19-25	10	17	27			
9	26-Mar 4		6	29			
10	Mar 5-11		9	33			
11	12-18		7	40			
12	19-25		11	40			

MC - Soil Moisture Content at beginning of week, % by weight.
RF - Rainfall
ET - Evapotranspiration
IR - Irrigation Requirement assuming 60% combined field, conveyance

Table 18 Irrigation Schedule Computation based on Soil Moisture Balance, Lateral A–Extra, Surallah, South Cotabato, Dry Season Corn Crop.

Wk. No.	Date	RF (mm/wk)	ET (mm/wk)	IR 40% EFF. (lps)	Time 40% EFF. (days)	IR 60% EFF. (lps)	Time 60% EFF. (days)
42	Oct 15–21	35	27				
43	22–28	40	29				
44	29–Nov 4	42	33				
45	5–11	32	25				
46	12–18	26	24				
47	Nov 19–25	22	26				
48	26–Dec 2	34	28				
49	Dec 3–9	25	22				
50	10–16	21	33				
51	17–23	19	24	340	7	344	3
52	24–31	18	29	289	7	381	5
1	Jan 1–7	27	25				
2	8–14	11	28	244	7		
3	15–21	11	27	231	6	344	4
4	22–28	24	23	208	4	343	3
5	29–Feb 4	9	25	383	7	293	3
6	Feb 5–11	10	24				
7	11–18	19	32				
8	19–25	17	27				
9	26–Mar 4	6	29				
10	Mar 5–11	9	33				
11	12–18	7	40				
12	19–25	11	40				
Total					**38**		**18**
Mean				**283**		**341**	

RF - Rainfall
IR - Irrigation Requirement assuming 40 % Efficiency.

Table 19. Farm ditch density for the original design of terminal facilities.

Turnout	Location Station	Area (has.)	Ditch Length MFD (m)	Ditch Length SFD (m)	Ditch Density MFD (m/ha)	Ditch Density SFD (m/ha)	Ditch Density Total (m/ha)
RAspl 1 (left)	1+408	27	300	560	11	21	32
RA 1 (right)	1+977	43	560	900	13	21	34
RA2 (left)	1+977	35	420	1060	12	30	42
RA3 (right)	3+000	32	660	1420	21	44	65
RA4 (left)	2+800	47	620	1520	13	32	45
RAspl 2 (left)	3+605	13	600	1440	46	111	157
RAspl 3 (right)	3+920	21	680	1400	32	67	99
RA5 end check	4+600	100	800	3280	8	33	41
Total		**318**	**4640**	**11580**	**156**	**359**	**515**

MFD - Main Farm Ditch

SFD - Supplementary or Internal Farm Ditch

Table 20. Farm ditch density for the proposed design of farm level facilities.

Turnout	Location Station	Area (has.)	Ditch length MFD (m)	Ditch length SFD (m)	Ditch Density MFD (m/ha)	Ditch Density SFD (m/ha)	Ditch Density Total (m/ha)
1	1+260 (left)	22	180	1200	a	55	63
2	1+977 (right)	37	820	1420	22	38	60
3	1+977 (left)	32	600	1240	19	39	58
4	2+800 (left)	32	620	1520	19	48	67
5	3+000 (right)	22	620	470	28	21	49
6	3+605 (right)	21	660	500	31	24	55
7	3+605 (left)	32	590	1440	18	45	63
a	4+245 (right)	18	620	1090	34	61	95
9	4+245 (left)	26	400	960	15	37	52
10	4+980 (right)	16	430	850	27	53	80
11	5+420 end check	19	380	950	20	50	70
Total		277	5920	11640	241	471	712

MFD - Main Farm Ditch

SFD - Supplementary or Internal Farm Ditch

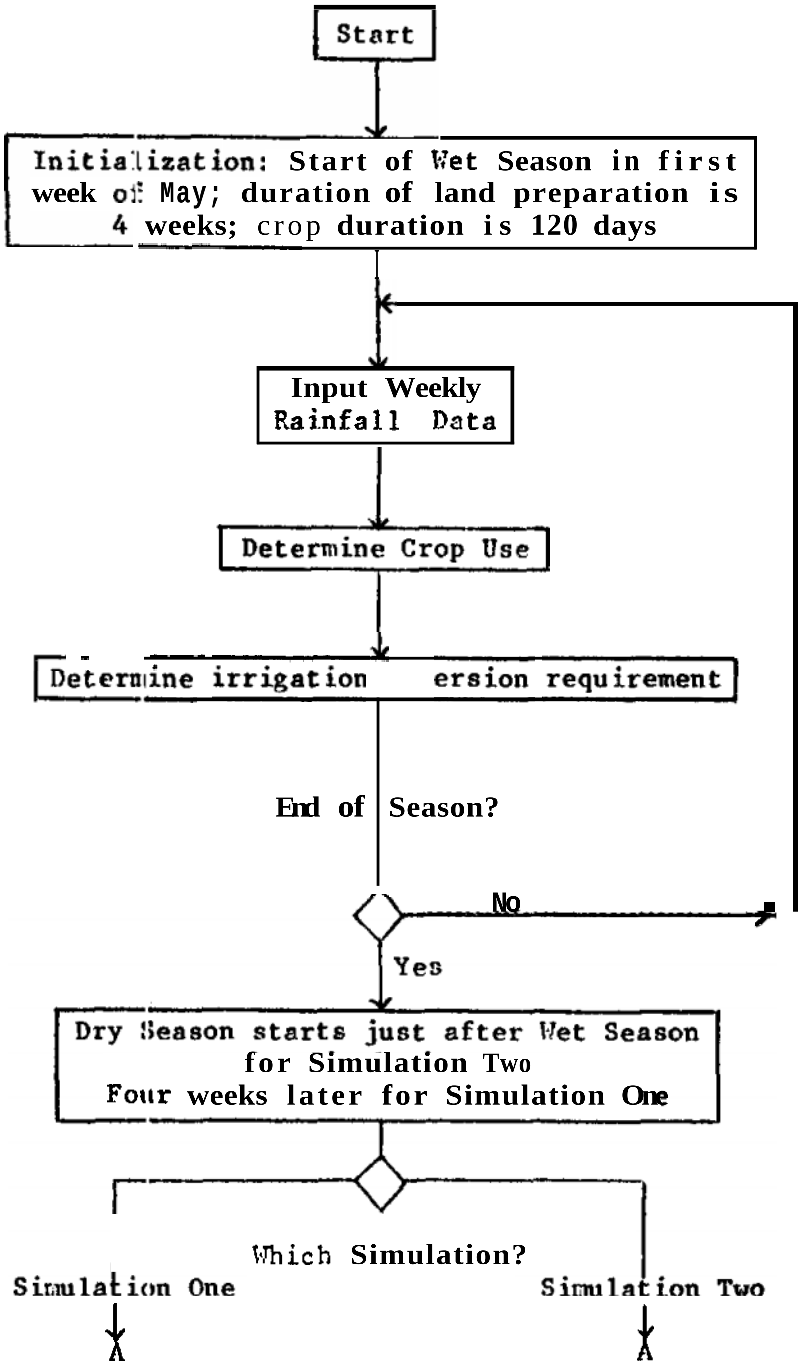

Figure A.1 Simulation flow chart for irrigated rice - irrigated corn cropping pattern.

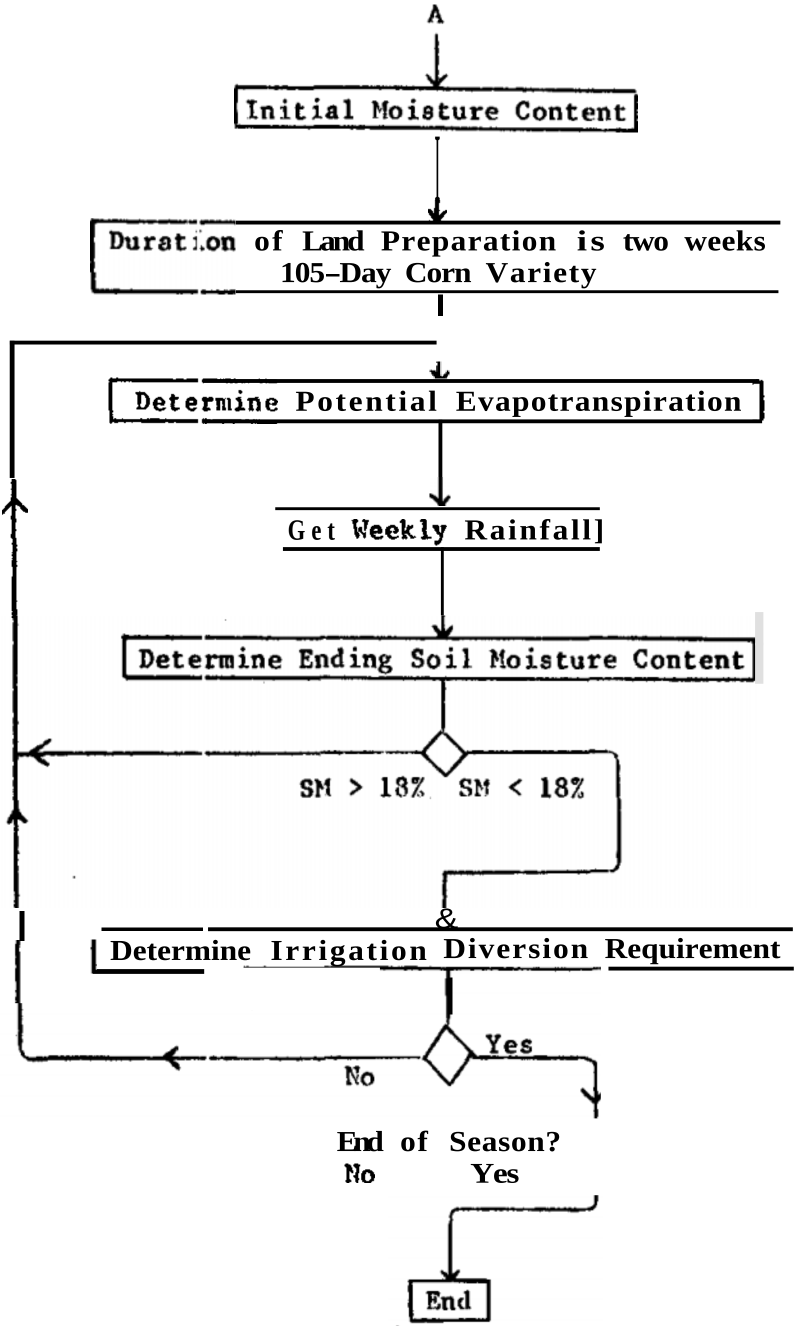

Figure A. 1 (continued)

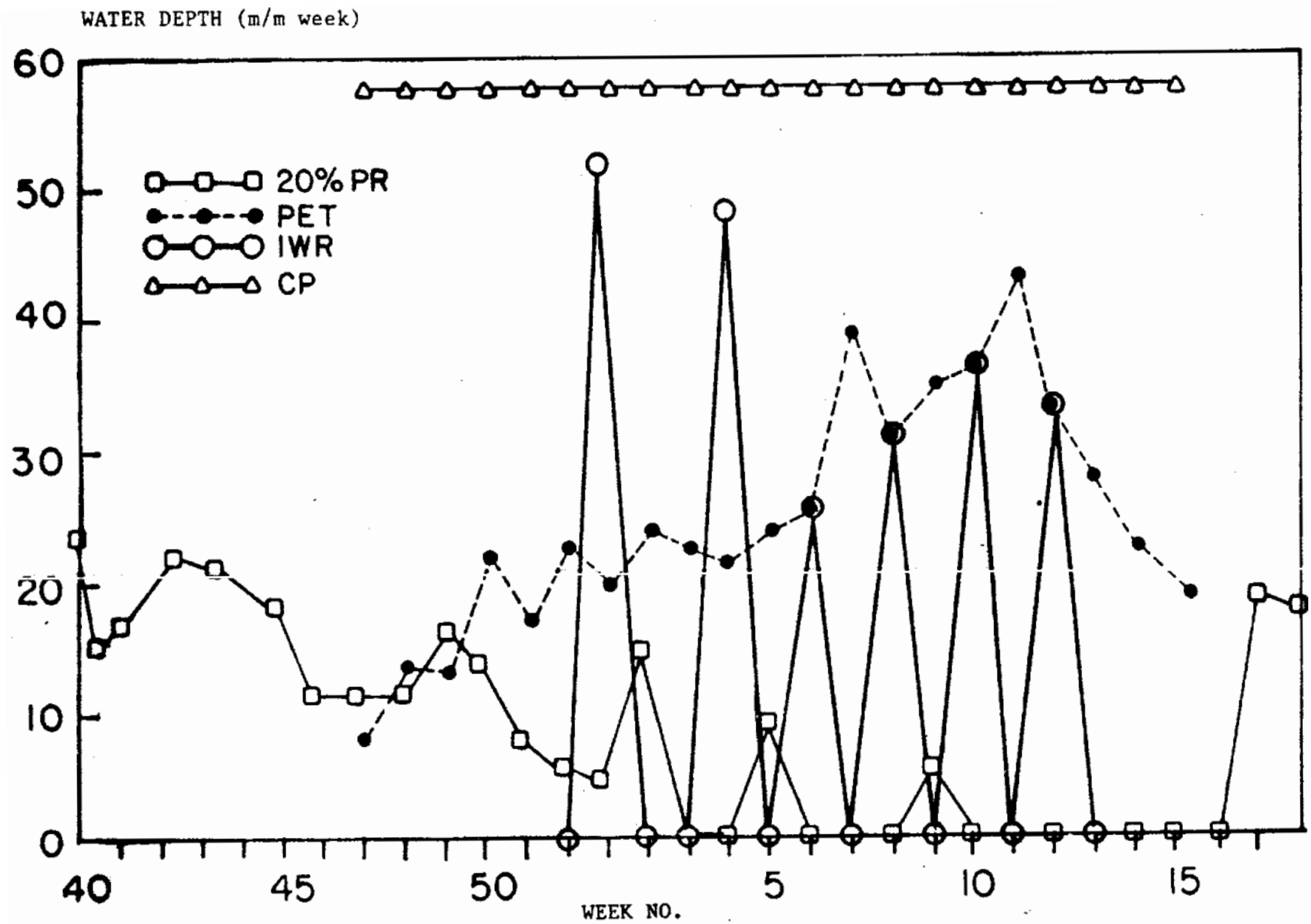

Figure A.2 Probable weekly rainfall (20% PR), potential evapotranspiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted late in the year.

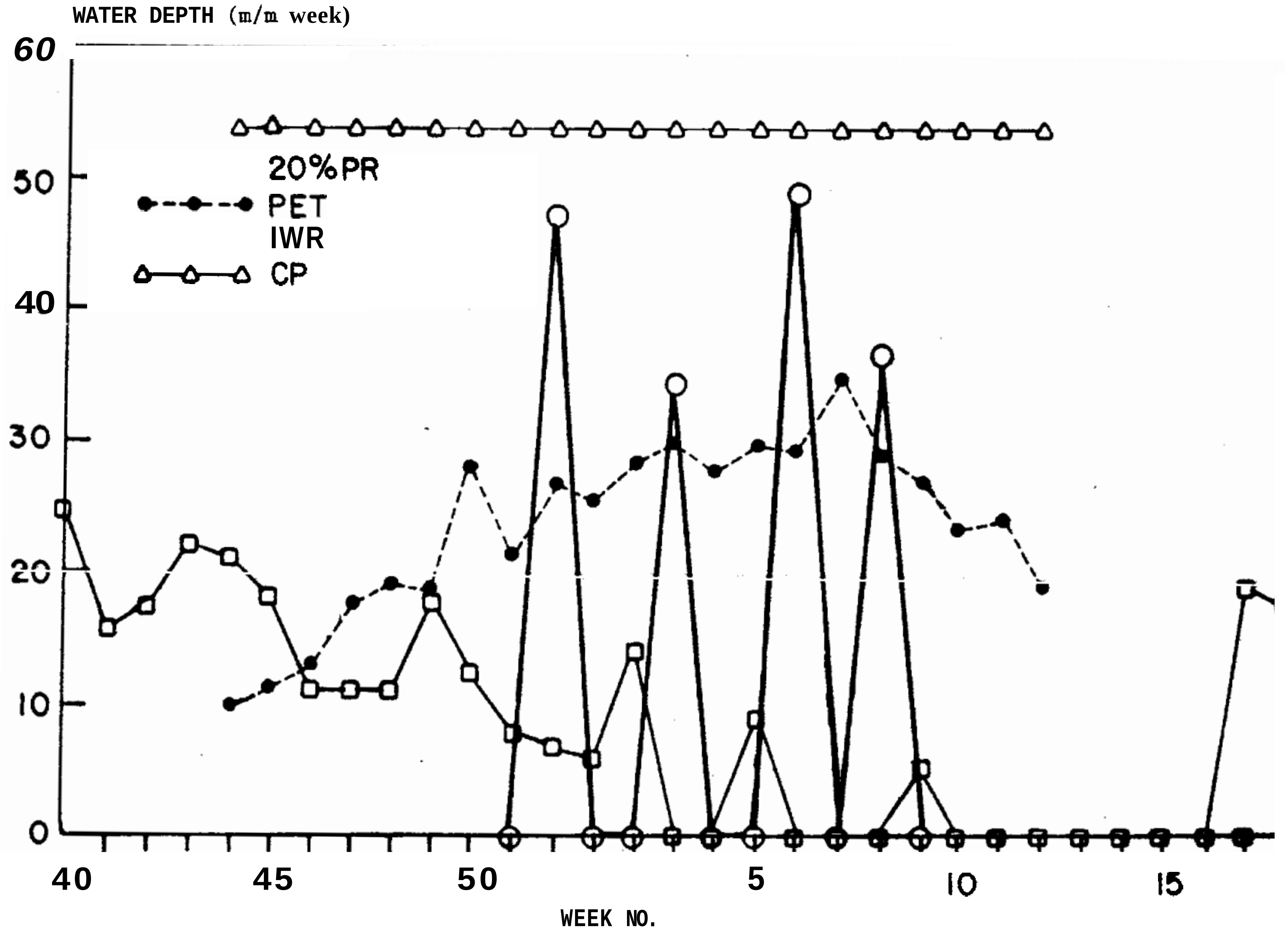

Figure A.3 Probable weekly rainfall (20% PR), potential evapotranspiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted early in the year.

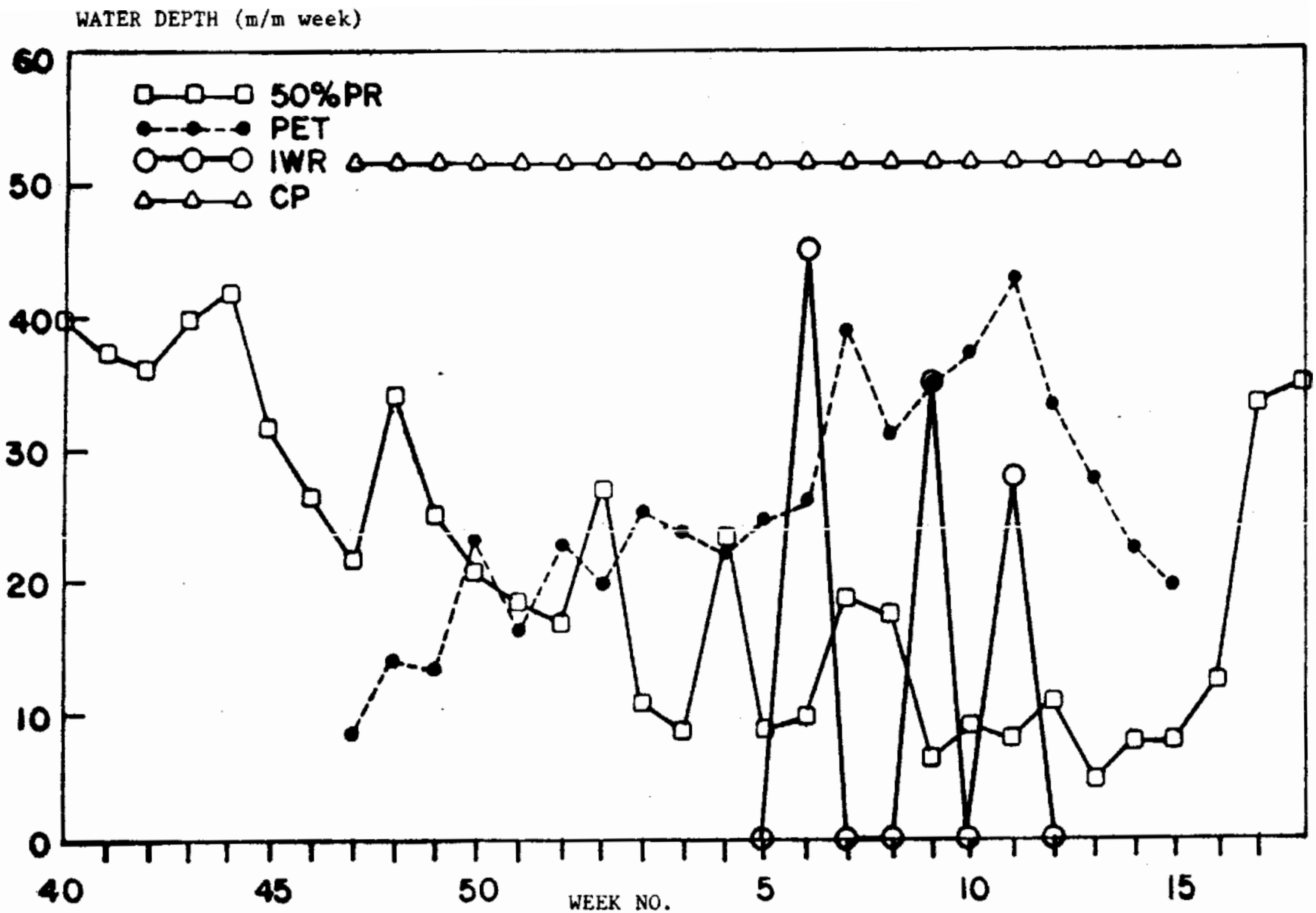

Figure A.4 Probable weekly rainfall (50% PR), potential evapotranspiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted late in the year.

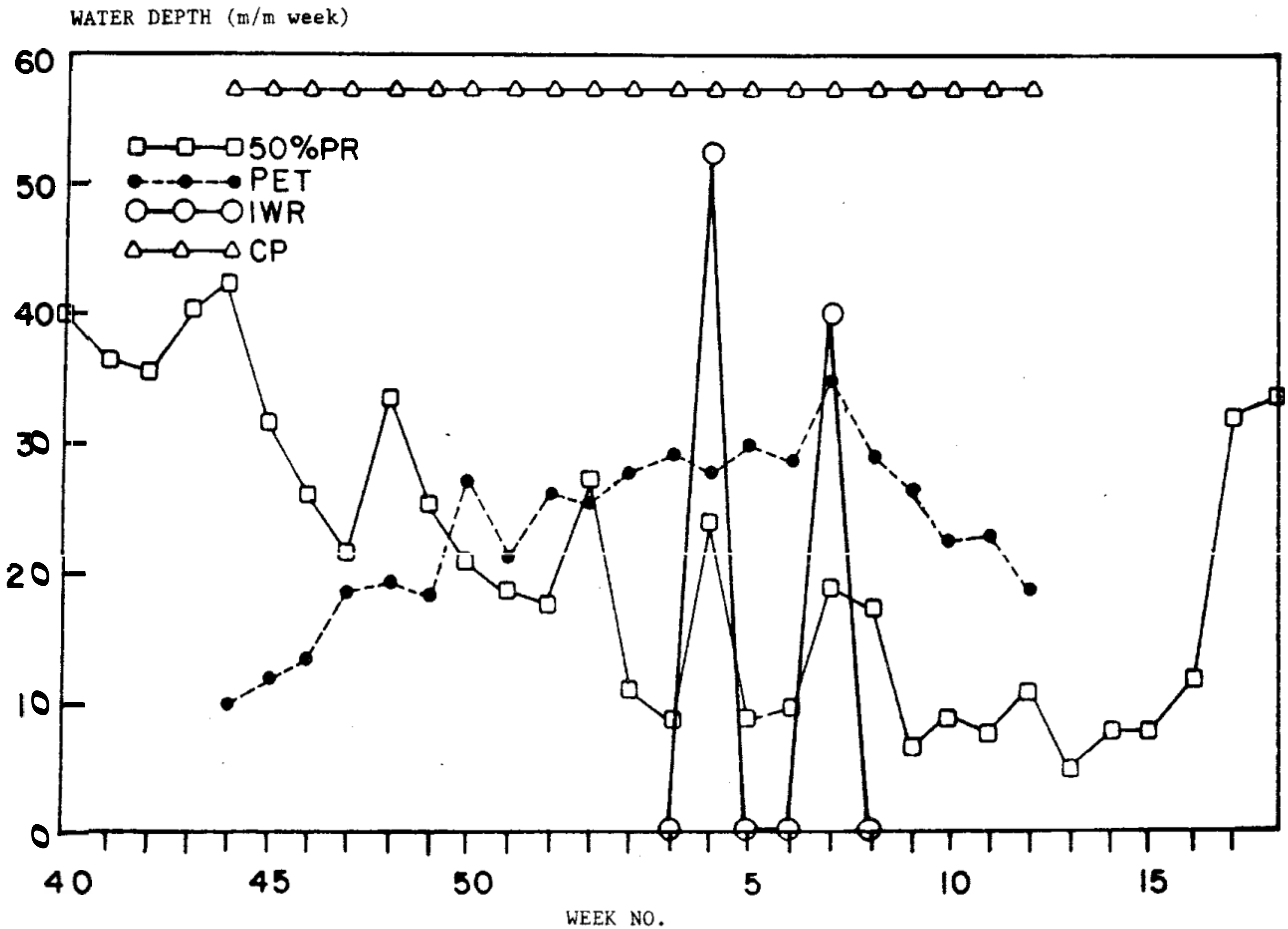

Figure A.5 Probable weekly rainfall (50% PR), potential evapotranpiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted early in the year.

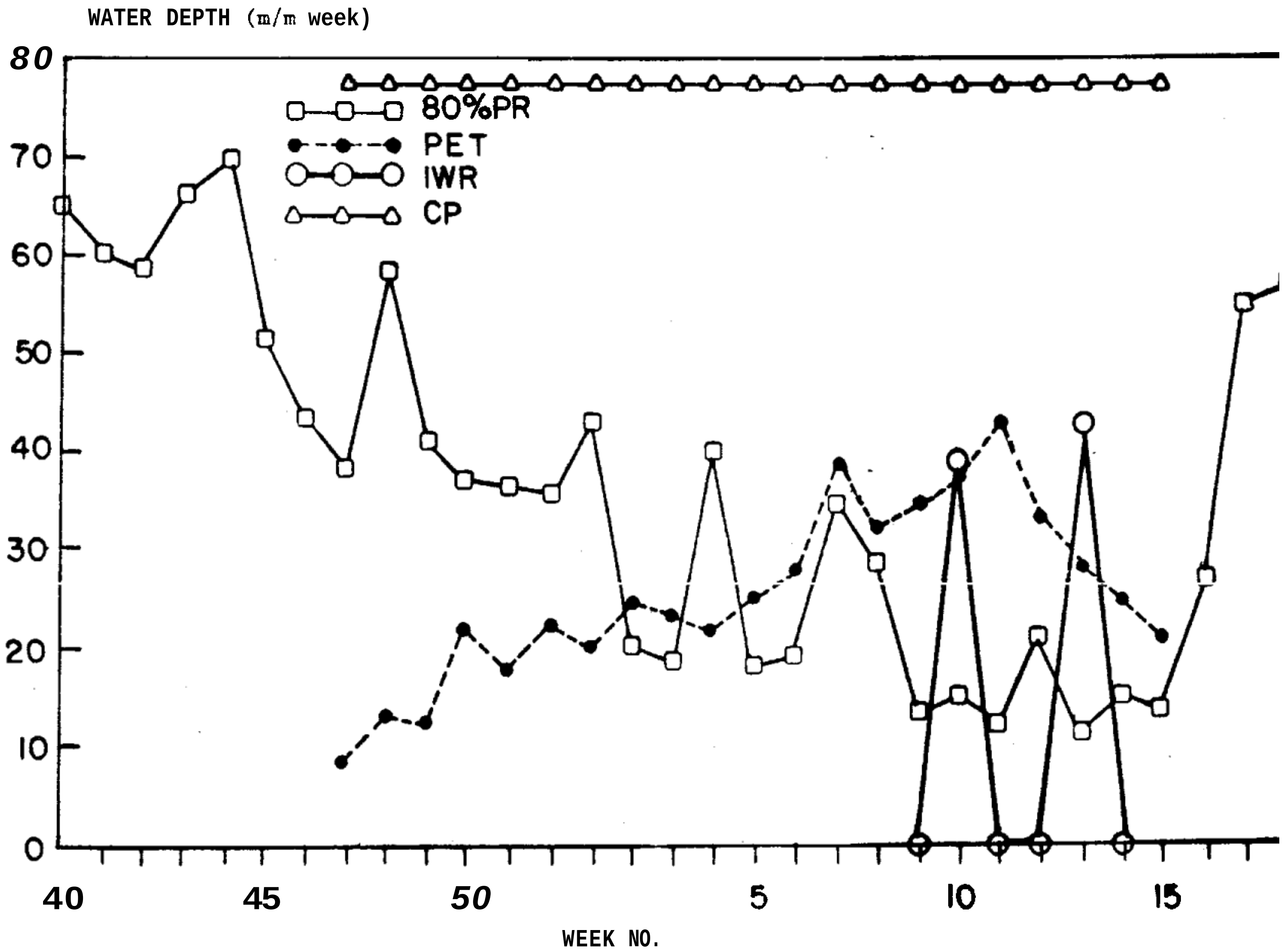

Figure A. 6 Probable weekly rainfall (80% PR), potential evapotranspiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted late in the year.

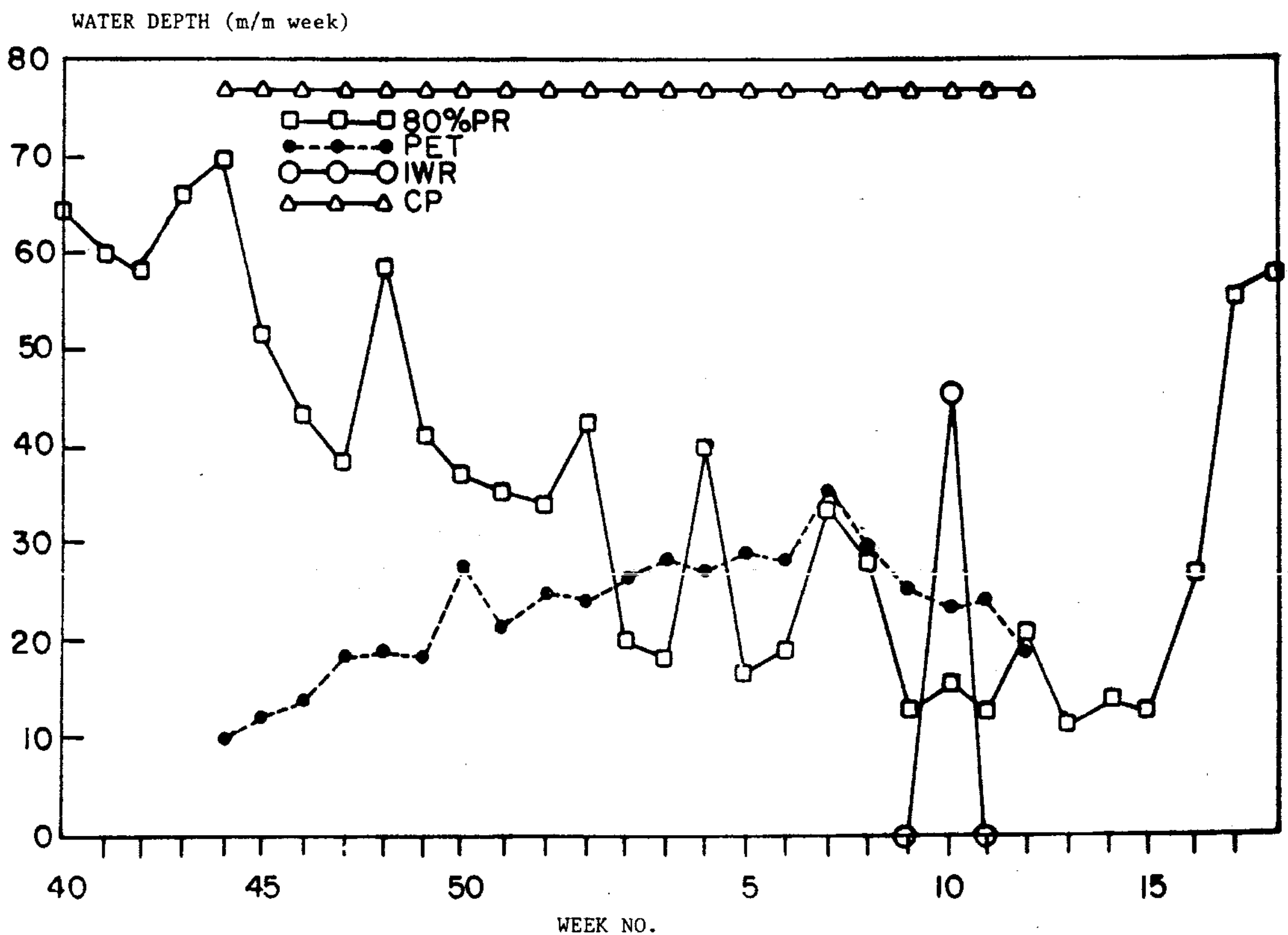

Figure A.7 Probable weekly rainfall (80% PR), potential evapotranspiration (PET), irrigation requirement (IWR), and cropping pattern (CP) for irrigated corn planted early in the year.