Crop Diversification in Irrigated Agriculture in the Philippines

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Foreword

Throughout South and Southeast Asia, in a great arc stretching from eastern India and Sri Lanka to southern China, and extending out to much of Indonesia, irrigated agriculture has traditionally been dominated by the production of rice.

In the 1980s perceptions of this situation as natural and more or less permanent have been changing, at least within government agencies. A set of policies, which are collectively referred to for brevity as "crop diversification," have been evolving. These have, at the functional level, twin aims: to increase the dry-season crop intensity on irrigated land by promoting its use for various crops that demand less water than rice does, and to encourage a more diverse crop pattern in the wet season.

The reasons for wanting to stimulate these changes are numerous, as this volume makes clear. These reasons vary between the levels of national policy, irrigation system management, and individual household needs. The present volume indicates many of them, and we should note here two over-riding goals: to enhance farm incomes, and to promote a more flexible agriculture that is better able to respond to demand as it is indicated by markets and price changes.

However, to introduce such change into irrigation systems that have for long been organized towards a rice monoculture is not simple. There are physical constraints deriving from the layout of irrigation facilities and the seasonal water-supply patterns; organizational constraints deriving from existing rules and procedures which are rice-oriented; human factors like the farmers' level of knowledge of how to produce and market the potential alternative crops; and many other aspects, ranging out to matters such as the availability of credit for the significantly higher input costs associated with some of the alternative crop regimes.

The International Irrigation Management Institute (IIMI) is highly interested in identifying sets of innovative practices that can help to solve these varied constraints and to attain the two over-riding goals mentioned above. As an exercise in the management of irrigation in its broadest sense, it is particularly challenging, because these problems impinge on several of the Institute's central values and principles, among them the enhancement of rural incomes, and the development of multidisciplinary, collaborative, and performance-oriented attitudes in irrigation management.

Over several years, IIMI has worked with irrigation agencies, especially in Indonesia, the Philippines, and Sri Lanka, to study these questions and evolve possible solutions. The Asian Development Bank (ADB) has been IIMI's principal financial supporter in these studies, and its consistent backing is gratefully recognized. The present monograph is one of the outputs of such a study sponsored by the ADB.

This monograph records the proceedings of a Philippine national workshop, held under the joint sponsorship of IIMI, the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), and the National Irrigation Administration (NIA), in October 1988. The papers presented here record the findings of research in many facets of the crop-diversification problem. These studies were undertaken by numerous institutions in the Philippines, including the event's main sponsors. It provides an in-depth treatment of one country's specific experiences with these questions.

Roberto Lenton
Director General
International Irrigation Management Institute

Opening Remarks

Dr. Roberto L. Lenton
Director General
International lrrigation Management Institute

Considerable effort has been devoted over the recent past on imgation management for diversified cropping. To date, considerable results have also been achieved in these studies.

The collaborative studies that IIMI and its partners have undertaken in the Philippines are part of a major multi-country study on irrigation management for crop diversification that are being undertaken in Indonesia, Sri Lanka, and soon in Bangladesh. **All** of these work have essentially the same objective - to develop better ways to manage irrigation systems **for** diversified cropping. **Thus,** the studies in the Philippines and this workshop itself are part of IIMI's worldwide efforts to improve the management and performance of irrigation systems in developing countries through the developmenf and dissemination of imgation management innovations.

This workshop illustrates three special features that characterize IIMI's work not only in the Philippines but in other countries as well. The first is the concept of partnership. IIMI's work in the Philippines has been based on partnership - with national institutions and more recently, with international institutions through the International Rice Research Institute. This partnership is what enables IIMI to be effective in the different countries in which it operates. Being a small institute with limited financial and staff resources, it is only through linking, joint venture and partnership with others, that IIMI is able to be effective.

The second feature of this workshop and of these studies that have been conducted in the Philippines is the concern **for** both applied field research in specific locations and the analytical thematic research. This facilitates the pooling together of the results from different locations and the insights derived from them. It is this workshop which allows IIMI to reflect on the results that have been achieved and it is this dual character of addressing both very specific applied field research and more analytical thematic research that characterizes the Institute's activities worldwide.

The third feature is the focus not only on technical issues but also on the wide range of management issues that must be addressed, if the development of effective ways to improve the management of irrigation systems is to be pursued. Thus, the studies that are being undertaken in the Philippines concentrate, not only on the management of water nor crops, but also on the management of organizations, finances and facilities.

Opening Remarks

Dr. Manuel M. Lantin
Assistant Secretary for Research and Extension
Department of Agriculture

Crop diversification is a strategy that the Philippine government, through the Department of Agriculture is adopting to promote and hasten agricultural development. It is one obvious approach to solving some of the problems of the country's agriculture, particularly those affecting a number of the country's important industrial crops such as sugar, coconut and rice. It is a strategy for attaining the goal of increasing productivity and farm income from a given piece of agricultural land which is main thrust of the Department of Agriculture. It is an answer to questions of skeptics who doubts the wisdom of breaking up large tracts of agricultural land into small production units farmed and managed by a number of people - the new landowner.

An example is presented herein. There is an irrigated farm in Capiz that is less than 7000 square meter:' In spite of its size, the farmer earns at least P70,000 indicating that it is a very productive piece of land. The farm is highly diversified.

The role of irrigation water in increasing productivity cannot be overemphasized. Irrigatioh,' unfortunately, has been associated with rice. When a dam or a water impounding structure is built, the purpose for which it was built is to be a source of irrigation water for rice and/or for hydro-electric power. The availability of irrigation water to a great extent causes shifts in cropping patterns or cropping systems to rice monoculture. This is not to undermine, however, rice as an important crop in the country and in Asia and the world. In spite of relative success the country has attained in rice production, there is still a need to continue the work done on rice research. However, agricultural development cannot proceed at the desired rate by depending on rice alone; no country has adopted that as a strategy. Moreover, there are still a lot of research to be undertaken in irrigation management to improve the efficiency of use of irrigation water in rice.

The issues on irrigation water management were highlighted in 1987 when there was rainfall and irrigation water shortage, because of a prolonged dry spell. The importance of researches in irrigation management for crop diversification can be further highlighted by one particular example that I know. This is with reference to corn production. Central Luzon is not really a corn production area, it is a rice area. However, there are areas there which can grow only one crop of rice not because it is not irrigated, but because the available water during the dry season is not enough to support another crop of rice. Some enterprising farmers then shifted to other crops like corn. The results of that shift in the cropping pattern was tremendous. Corn with about 2 or 3 flushes of irrigation can yield at least 5 t/ha. Applying irrigation water sufficiently enough to support a crop of corn would certainly give good results. Such is an illustration of using irrigation water for crops other than rice.

The Department of Agriculture underscores the importance of irrigation management. As a result, the Bureau of Soils reoriented its mandate and was renamed the Bureau of Soils and Water Management.

Workshop Rationale and Objectives

Dr. Alfredo B. **Valera**
Resident Scientist
IIMI-Philippines Program

Everybody present here share the mutual concern for the opportunities to increase productivity in irrigation systems particularly during the dry season. From IIMI's perspective, the concern **is** on irrigation management, because that is IIMI's mandate. PCARRD's concern is to support research and development that will generate information and technologies that would assist the different government agencies promote and the farmers in particular to have a more profitable production. From NIA's perspective, it is their desire to make their imgation systems more productive by providing effective, timely and adequate irrigation for crops during the dry season. From the perspective of the Department of Agriculture, it is the overall productivity, combining all these technologies and practices which will enable the collective efforts of all farmers to make the economy of the country self sufficient, not only in rice but in other crops **as** well.

This workshop specifically aims to: (1) assess the results of studies on irrigation management for crop diversification conducted by IIMI and other research institutions in the Philippines; **(2)** review the publication, State of the Art/ Abstract Bibliography on Water Management for Crop Diversifcation; **(3)** formulate guidelines for Irrigation Management for Crop Diversification; and (4) recommend future plan of actions which will lead to a more productive endeavour with regard to research and the implementation of, recommendations particularly by the National Irrigation Administration.

Executive Summary

National Workshop on Irrigation Management for Diversified Cropping
5-7 October 1988. Puerto Azul, Cavite. the Philippines

Concern for irrigated non-rice crop production in the Philippines stems out of the perceived potential to increase crop production, particularly in irrigation systems where water is not sufficient to sustain a good crop of rice. Non-rice crops have been identified as an alternative to rice to maximize utilization of existing resources and augment rice production. However, there are constraints that have to be solved or mitigated before a viable irrigated crop diversification program can be successfully attained.

Constraints include lack of government policies and inadequate facilities and procedures to irrigate non-rice crops in existing rice gravity irrigation systems. Researches are being undertaken and technologies on irrigated crop diversification are being developed to find ways of mitigating these constraints. One study being conducted, through a technical assistance grant (T.A. No. 859 PHI) to the Government of the Philippines by the Asian Development Bank (ADB) is the "Study on Irrigation Management for Diversified Crops" as implemented by the International Irrigation Management Institute (IIMI) in collaboration with the National Irrigation Administration (NIA) and the consortium of state colleges and universities as coordinated by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). A workshop was held to primarily assess the results of the above study and related studies of other institutions.

The workshop assessed the interim results of the IIMI study and also the results of studies from other institutions. An IIMI-PCARRD publication, the *State of the* Art *(SOA) and Abstract Bibliography (AB) on Water Management for Crop Diversification in Irrigated Rice-based Cropping Systems,* was also discussed. The draft guidelines on *Irrigation and Production of Selected Upland Crops* and on *Irrigation Management for the Operation of Systems for Diversified Crops* were likewise discussed. Plans for the remaining period of the IIMI study were discussed and recommendations were made.

A synthesis of the studies presented resulted in the identification of crucial issues in irrigated crop diversification. There were three levels of objectives identified: a) the national or governmental b) the irrigation systems or agency and c) the personal objectives of farmers. All of these objectives have to be considered in viewing the subject matter. Moreover, experiences from other countries should also be looked into, to expand the possibilities of attaining a rational program in irrigated diversified cropping.

Reactions to this synthesis were provided by representatives from the NIA, the Department of Agriculture (DA) and the National Economic Development Authority (NEDA). The NIA representative expressed the need for technologies in irrigation as well as for non-rice crop production that will convince farmers to adopt irrigated diversified cropping during the dry season. The concern for farmers' acceptance of irrigated non-rice crop production and the resulting profitability to farmers have to be worked out. The DA representative responded by expressing the department's major concern for the farmers with lesser resources, i.e., rainfed farmers. However, the reduction of irrigation costs in line with improvement in irrigated non-rice crop production technology were two concerns that were expressed. The NEDA representative expressed the need for a more flexible policy with regard to crop production support from the government. The farmer should be given the option on what crops to produce. Crop diversification should be viewed in a regional context within the Association of Southeast Asian Nations (ASEAN) to avoid problems of shortage or oversupply of commodities within the regional market. Considering costs and benefits in all of the researches will alleviate the conflicting results obtained in these studies and will become the basis for decision making in the introduction of new technologies in existing irrigation systems. The role of non-governmental organizations is not only encouraged in research but also in other decision making processes of the government.

The second half of the workshop dealt with the review of SOA/AB publication, draft guidelines for the irrigation methods and production of selected non-rice crops and irrigation management for the operation of systems for diversified cropping, background information on the study systems, and planning for the component studies and field testing of procedures for the 1988/89 dry season. In the discussions of the SOA/**AB** on *Water* Management *for* Crop *Diversification* in Irrigated Rice-Based Cropping *Systems*, several comments and suggestions were raised. Foremost, was the inclusion of information from other countries. The paucity of information on irrigation system management **for** diversified crops was noted. Definition of terms was also missing. The concern for irrigation system design for diversified crops was also not included. However, instead of revising this publication, the comments and suggestions will he accommodated in the forthcoming publication of PCARRD which is the Philippines Recommends for *Irrigation* Management *for* Crop Diversification.

The only comment made with regard to the draft guidelines **for** the irrigation and production of selected non-rice crops was in the case of furrow irrigation. Levelled fields are important to rice but not to upland or non-rice crops whereby a minimum gradient is needed for furrow irrigation to become effective. It was suggested that in areas where furrow irrigation is not practiced, the existing irrigation method can still he improved.

In the draft guidelines for irrigation management for the operation of irrigation systems for diversified cropping, several issues were discussed. The use of the incomplete gamma analysis for weekly rainfall probabilities, inclusion of the status of existing irrigation canals and structures in the determination of water demand, assessment of river flows, and the participation of the farmers through the irrigation association in the allocation, delivery and implementation of irrigation schedules, were the major points made in the discussion in this part of the workshop. These issues were considered significant in drafting the procedures for irrigating non-rice crops in existing systems.

Among the study sites, only the background papers on the Allah River Irrigation Project (ARIP), Banga River Irrigation System (BARIS), Laoag-Vintar River Irrigation System (LVRIS) and the Bonga River Irrigation System Pump No. 2 (BP#2) were presented and discussed. There was no discussion on the Upper Talavera River Irrigation System **(UTRIS).** Under **ARIP,** two issues discussed were the reluctance of farmers to grow irrigated non-rice crops and the very coarse soil for non-rice crop production. The only way to encourage farmers to produce non-rice crops was by limiting the water supply and staggering the cropping schedule. Due to the availability of rainfall even during the summer months, farmers preferred to grow rice. Under BARIS, siltation was the main problem which was also a concern for the watershed of the irrigation system. Earlier, NIA proposed to undertake watershed management in all of the NIA systems. The proposal for a Watershed Management Department at NIA will facilitate the improvement in the availability of water in rivers being diverted for use in all of the irrigation systems. Under LVRIS, the issue raised was the density of irrigation facilities. Due to the very dense area farmed (average farm area is less the 0.3 ha), the areas were smaller (1-3 ha) per turnout. The cropping intensity reached as high as 300% in some sections of LVRIS. The issue of other non-rice crops besides garlic was also raised. Peanut had a potential under LVRIS, however, the long growing period inhibited farmers from planting this crop. With garlic as a second crop, a third crop of mungbean was feasible and preferred. Under BP#2, the cost of pumping irrigation water was raised. With the higher cost of water, non-rice crops were more advantageous to plant. However almost half of the dry season area in this system was planted to rice in spite of the higher cost of irrigation water.

In the planning portion of the workshop, several major issues were raised for consideration in the component studies to be undertaken by IIMI during the 1988/89 dry season. These were: monitoring of price fluctuations **as** it affects profitability of farmers in a given season; an assessment of the incremental cost of management for growing and irrigating non-rice crop compared to rice during the dry season (at the farm and system level); the appropriate irrigation fee for non-rice crop; and the use of simulation techniques to arrive at the best irrigation method for a given irrigation system and to determine the adequacy of irrigation facilities. The participants considered the issue on the assessment of incremental management cost for growing irrigated non-rice crop during the dry season as a significant undertaking during the 1988/89 dry season. Studies on this aspect was recommended to IIMI.

In the field testing of the promising practices for effective irrigation management for diversified crops, several suggestions were made. The adaptabilityofsoybeans and improved open pollinated corn at ARIP and BARIS will have to be ascertained. The field testing of improved open-pollinated corn will provide farmers in these systems an alternative to hybrid corn which requires lesser input which may increase the income of the farmers. The superintendent of BARIS and ARIP assured the group that these crops will be provided with irrigation water.

With regard to the use of the incomplete gamma function for rainfall analysis, the assignment of probability levels has to be verified among the systems being studied to assess its operational applicability in other systems as well. The use of the computer aided mapping program developed by IIMI will be transferred to end users by training NIA staff in its use and applicability. Field testing of procedures to facilitate equitable water distribution for both rice and non-rice crops at LVRIS and UTRIS was given emphasis.

The need for a multidisciplinary approach was emphasized. Five sectors which should be looked at interrelatedly were: 1) agronomic and agricultural, 2) economic, 3) social, 4) engineering and 5) institutional sectors. The agricultural sector will provide the technology for the production of the appropriate crop in a given location. The economic sector will deal on the usefulness of the crop or the availability of the market. The social sector shall be concerned with the farmers' welfare in terms of satisfaction with the income derived from the particular crop. Engineering sector will deal on the modifications of the existing facilities to effectively produce the crop with adequate water supply. The institutional sector will deal with the need for new organizations or modification of existing ones.

Experiences in irrigated crop diversification in other countries was suggested to be referred to. Government policies that allows flexibility in supporting crop production favorable to both farmers and consumers were also needed to enhance crop diversification. The need for a thorough study on the farmers' decision making and how commodity prices affect farmers' behavior were also stressed. Furthermore, a study on the market forces pertaining to the non-rice crops should be explored together with the amount that the market can absorb at the level of import substitution.

Drainage was one of the issues that was not mentioned in the workshop. This issue was deemed significant since non-rice crops are very susceptible to waterlogging. Drainage will have to be considered in future studies for irrigated crop diversification. This was not considered in the workshop since most of the studies were focussed on the dry season where irrigation is the major concern.

There were also issues raised regarding irrigation fees as incentives for diversifying, water supply denial as another incentive for non-rice crop cultivation and planting of non-rice crops as a water saving practice. Considering these issues, a better understanding of the factors and sectors involved in irrigated diversified cropping and directions for further studies were achieved. Understanding these directions will lead to better research which is expected to contribute to the economic well being of the Filipino farmers.

Socio-Technical issues in Diversifying Rice-based Irrigation Systems

Tolentino B. Moya and Senen M. Miranda[1]

Abstract

Since the early 60s many rice-producing countries in Asia have launched agricultural diversification projects to stimulate farm productivity. However, these projects have succeeded in only a few countries. Perhaps, the pressures to diversify agriculture, especially the irrigated rice systems, were less compelling then than today.

At present, the water supply scarcity in rice-based irrigation systems and the low price of rice in the world market will constrain irrigation personnel and farmers to veer away from monoculture rice systems. As rice irrigation systems can hardly maintain productivity and equity under limited water supplies, they will diversify into less waterdemanding non-rice crops. Similarly, as fanners continue to reel under low profits, sometimes losses, from rice farming, they will consider crop diversification.

This paper examines the driving and restraining forces in crop diversification, especially in irrigated rice-based systems. Technical, social and institutional issues in crop diversification are being presented to provide insights on (1) how existing rice-based irrigation systems can be operated or rehabilitated to permit cropping systems flexibilities and / or (2) designing and constructing new rice-based irrigation schemes for crop diversification.

Background

Most rice-based irrigation systems in Asia experience limited water supplies because of the combined effects of erratic climatic behavior, overcommitted water supplies, and deteriorated physical facilities and structures. Erratic climatic behavior has greatly reduced the amount of rainfall resulting in unfilled reservoirs, subsiding river regimes and receding groundwater level. Some irrigation systems experience tight water supplies because their service area are larger than what the expected water supplies can adequately provide for. Or, the predicted water supplies have been committed to a number of competing uses, as in multipurpose irrigation projects.

Confounding the scarcity of system water supplies are rundown physical facilities and structures. Many broken and inoperable structures and facilities clutter rice irrigation systems, so that much less water supply can be captured and transported resulting to low efficiency. The structural capability of many irrigation systems has, indeed, deteriorated that the high physical control required for handling limited water supplies to competing uses is difficult to produce.

The foregoing instances indicate alteration of the original hydraulic regime on which design and operation of irrigation systems has been based. To manage hydraulic changes, a few well-operating systems, like the old farmer-managed systems, complement structural control deficiency with organizational capability. Most likely, these systems have already attained internal and external operational homeostasis, which other irrigation systems find elusive to achieve.

Meanwhile, advances in rice-based production technologies have benefited not only the adequately-watered environment but also the less-watered environment. As a result, rice production

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has risen to a level that reduces price of rice in the world market. To keep rice price from further deterioration, monoculture rice fanners should diversify into non-rice crops?

Non-rice crops are less waterdemanding. To harvest a field of non-rice crops may require much less total water than an equal field of flooded rice. Non-rice crops can maintain physiological growth with water as low as one-fourth to one-third of that supplied to rice.

Because of low field water requirement and moderate tolerance to water deficits, non-rice crops can be a means to maintain productivity and equity of irrigation systems with limited water supplies. Government planners and irrigation practitioners are considering crop diversification, now as a vehicle of sustainable agricultural development.

Technical Issues

Technical issues in crop diversification in rice-based irrigation systems originate from the intricate and differential relationships among edaphic, climatic, hydrologic, biotic and agronomic properties of flooded rice environment and dryland non-rice production systems. The technical and operational properties endogenous to rice-based irrigation systems add to the complexity. This section starts with technical issues relating to basic soil-plant-water relations.

Soil-Plant-Water Relations

Plants. Most terrestrial plants, except rice, need aerated soil for growth and development. Rice can harness oxygen directly from the atmosphere through its hollow stem and supply it to its roots at a rate sufficient to sustain respiration under submerged soil conditions (Van Raalte, 1956; Jensen et al., 1967; Yoshida, 1981; Kramer, 1983). Rice can perform anaerobic respiration, too (Johnson et al., 1974). But due to rice's ability to fully oxidize rhizosphere with atmospheric oxygen, flooded rice develops shallow root system, about 20 cm for lowland rice (OToole and Chang, 1978).

Shallow root system partly explains rice's susceptibility to drought, particularly at soil moisture below saturation (IRRI, 1972; Wickham, 1973a; Wickham, 1974; Wickham and Sen, 1978). On the contrary, rice can tolerate excess water, ranging from saturation to 15-cm submergence; water above 15 cm depresses rice yield (De Datta and Williams, 1968; Williams, 1969).

Owing to physiological characteristics, keeping the soil flooded is the most logical water management strategy for rice.

Unlike rice, the above-ground parts of non-rice crops cannot fully supply the oxygen requirements for normal respiration. Non-ricecrops, must therefore, obtain additional amounts of oxygen from the soil to augment the amount tapped from the atmosphere. To satisfy another growth process, photosynthesis, non-rice crops also need soil water. Thus, for normal growth and development, non-rice crops require favorable air-water balance in the soil. Waterlogging, as well as water deficits, will seriously injure non-rice crops.

Only a deep well-drained soil can satisfy the soil air-water requirements of non-rice crops. Air-water balance in the soil is affected by soil physical properties, particularly soil texture and soil structure.

Soils. Non-rice crops require an approximate soil tilth — one that is adequately aerated but sufficiently water-retentive. Since it highly influences air and water transmission capacity of soils, soil texture limits soil tilth (Hillel, 1982; Kramer, 1983; Hausenbuiller, 1978).

Soils with more sand separates permit higher air and water mobility. Sandy soils have good infiltration, internal drainage, and aeration capacities but have low water-retention capacity'. On the other hand, the high clay content of some soils impedes water movement. Consequently, clay soils have low infiltration and poor internal drainage that restrict aeration capacity. So, clay soils have high water-retention capacity. Because soil texture is a permanent soil physical property, it can be a determinant of soil tilth, and thus of non-rice crop cultivation.

Managing structure of rice soils relaxes aeration and tillage constraints that soil texture poses

[2]Non-rice crops, diversified crops, upland crops, highland crops and dryland crops are interchangeably used to denote crcps that grow and produce best in aerobic soil conditions.

'The aeration capacity of a soil indicates its potential for free gas exchange with the atmosphere. It must not be confused with soil porosity which is the volume fraction of gas to the total soil volume. The larger proportion of macropores rather than the total porosity is more important for air and water mobility in the soil. See Donahue, et al. (1977), Hillel (1982), and Hausenbuiller (1978).

to non-rice crop cultivation. Soil structure refers to the size, shape, and arrangement of soil particles to form compound particles and the size, shape, and arrangement of compound particles (Donahue et al., 1977; Brewer and Sleeman, 1960).

From agronomic viewpoint, crops to be planted depend on soil structure. Puddled soil has the best structure for growing rice because it restricts water movement (Sanchez, 1978b; De Datta and Sharma, 1980). Only with adequate drainage or after thorough land preparation can non-rice crops grow on previously puddled soils since they are intolerant of waterlogging, particularly at establishment and reproductive periods (Pereira, 1956; Herrera, et al., 1980).

Soil structure partly determines soil workability or trafficability. Wet puddled soils have poor trafficability when tilled for upland crops. When dry, puddled soils are too massive or heavy to he prepared well. So, puddled soils, due to poor workability prolong turnaround time — the period that lapses between any two successive crop cultivations. On account of poor workability of puddled soils, the potential of an extended growing period, which crop production technologies made possible, is foregone.

Technical and Operational Attributes of Rice-Based Irrigation Systems

Water productivity. Under similar atmospheric demands, soil and water management practices, and growth duration, rice and non-rice crops require equal amounts of water to fully mature (FAO, 1979; Wickham and Sen, 1978). Rice, peanut, onions, soybeans, tobacco and tomato can fully mature with 350-750 mm of water under controlled environment (Table 1).

Under controlled conditions, the consumptive *use efficiency* of rice ranges from 0.70-1.10 kg/m^3 (FAO, 1979).

However, productive efficiency of crops is more important than consumptive use efficiency.[1]

***Table* 1.** Basic water requirements of rice and some dryland crops

Crop	Growing period (day)	Basic water** requirements (mm)	Water productivity (Kg/m^3)	Yield	Moisture (%)
Rice	90-150	350- 700	0.7- 1.1	paddy	15-20
Peanut	90-140	500- 700	0.6- 0.8	unshelled nut	15
Corn	100-140	500- 800	0.8- 1.6	grain	10-13
Onion	100-140*	350- 550	8.0-10.0	bulb	85-90
Sorghum	100-140	450- 650	0.6- 1.0	grain	12-15
Soybean	100-130	450- 700	0.4- 0.7	grain	6-10
Sugarcane	270-365	1500-2500	0.6- 1.0	sugar	0
Sunflower	90-130	600-1000	0.3- 0.5	seed	6-10
Tobacco	90-120*	400- 600	0.4- 0.6	cured leaves	5-10
Tomato	90-140*	400- 600	10.0-12.0	fresh fruit	80-90

*Plus about one month nursery period
**Evapotranspiration
Source: Food and Agriculture Organization of the United Nations (FAO). 1979. Yield response to water. Rome.

[1] Consumptive use efficiency is the ratio of a crop's economic yield to its total evapotranspiration demand. On the other hand. productive efficiency is the ratio of a crop's economic yield to the total field water use.

Moya and Murray-Rust **(1985)** compared the seasonal productive efficiency of rice in different types of Philippine irrigation systems (Figure 1). For wet season rice, productive efficiencydoes not significantly differ among types of system, about 0.20 kg/m^3. For dry season **rice,** productive efficiency varies among types of system, fluctuating from 0.12 kg/m^3 for diversion systems to 0.42 kg/m^3 for a deepwell system, like P-27 in Guimba, Nueva Ecija, Philippines?

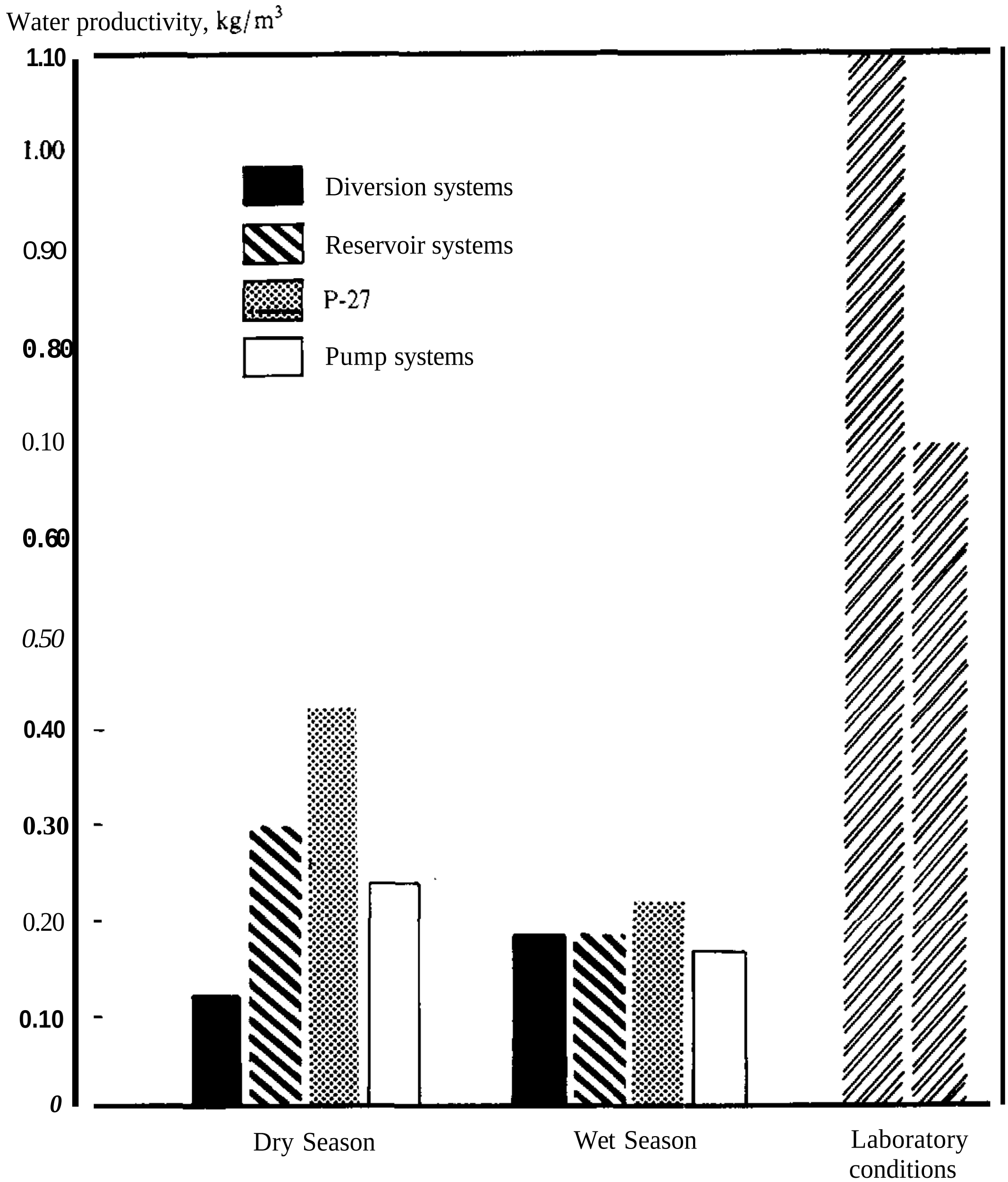

Figure *1*. Comparative rice yields per unit of water supplied, different types of irrigation system and under ideal conditions.

'The low productive efficiency of diversion systems was attributed to the conservative estimates of serviceable area and to the preoccupation to reduce area to maintain high relative water supply.

Productive efficiency of field rice did not even equal one-half of consumptive use efficiency. The efficiency gap indicates possibilities for increasing water productivity of irrigated rice-based systems.

The same study reported that productive efficiency of dry season corn in P-27 was nearly three times that of rice (Figure **2).** Furthermore, consumptive use efficiency of corn was about four times the productive efficiency of rice. Therefore, productivity of limited water supplies in irrigation systems will increase by cultivating corn — and other non-rice crops.

The rice's physical environment. As a compromise between cost of irrigation development and size of command area, rice-specific irrigation systems are generally situated on heavy soils (Wickham and Takase, 1978). The maximum area that can he commanded at the lowest cost are the flat lands which are usually situated on deltas and floodplains with heavy clay soils. Similarly, phreatic **or** fluxial lands are usually found on these landforms.

Although heavy clay soils with seepage and percolation (S&P) rate of up **to** 3 mm/day dominate most irrigated rice systems (Wickham and Sen, 1978), soils with good internal drainage can he also found. Soil with good drainage exists in the Chin-nan Irrigation Scheme in southern Taiwan (Hai-Shen, 1987). Ninety-two percent of Chin-nan service area rests on sandy loam to silt loam soils: the remaining 8% on clay soils.

Dual and diversified land classes are found in irrigation systems in the Philippines (NIA, 1976). Dual lands provide good soil environment **for** growing rice during the wet season and non-rice crops during the dry season. The rate of S&P in dual lands is high but does not exceed 8 mm/day. On the other hand, diversified lands can be planted to non-rice crops during both wet and dry seasons. The rate of **S&f** in diversified lands is greater than 8 mm/day.

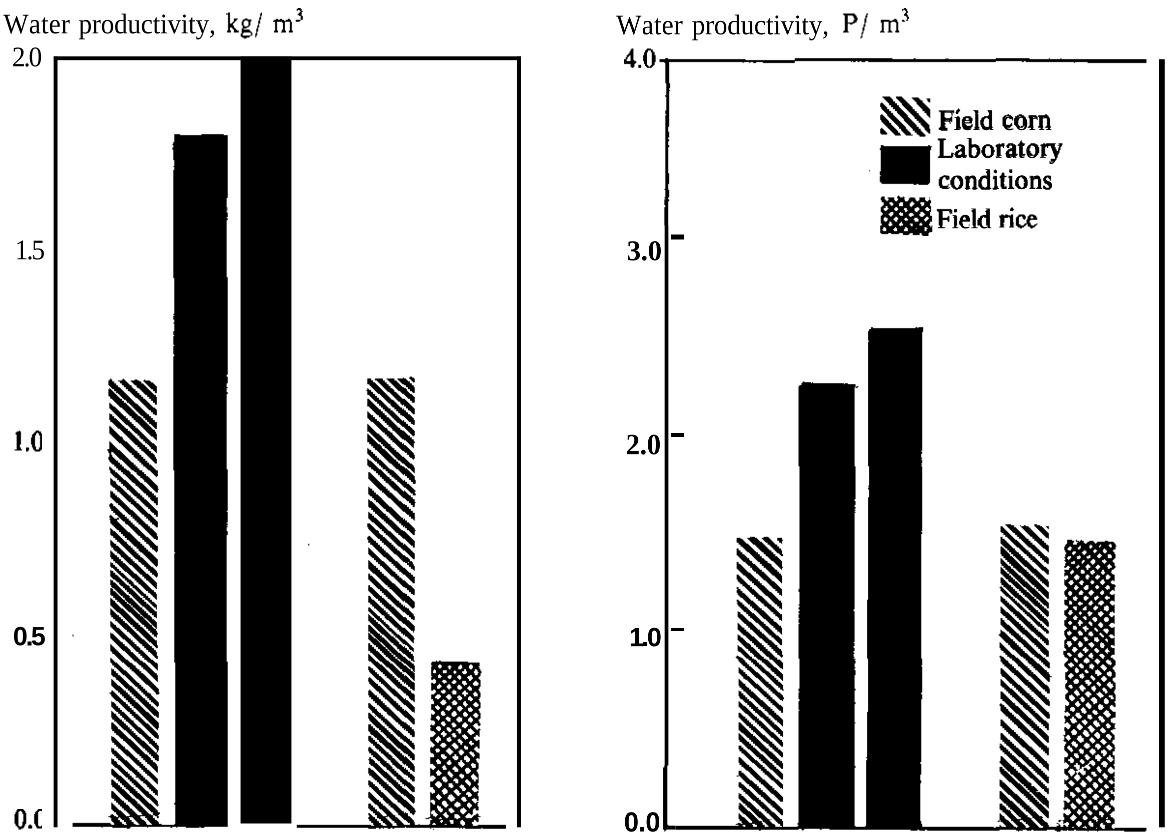

Figure 2. Productivity of water supplied to corn and rice.

Since clay soils have poor drainage properties and are dominant in most rice-based irrigation systems, there may be limited areas suitable for non-rice crop cultivation. This limitation is aggravated by puddling, the universal method of preparing irrigated rice land.

Puddling destroys the macropores and decreases soil air capacity, resulting in a closer packing of soil particles (Sanchez, 1973a) and decrease in hydraulic conductivity (Ghildyal, 1978). Harwood (cited in IRRI, 1985) studied the potential for multiple cropping of different soil textures puddled to different degrees under limited and adequate water (Table 2). Sandy loam (2:1 clay) and silt loam (1:1 clay) soils have good multiple cropping potential for a number of non-rice crops provided puddling does not increase the bulk density by more than 4%.[6]

On the other hand, clay soils that have been puddled to the point that bulk density increases by more than 12% have low potential for non-rice crops. Drying these rice soils naturally to a moisture consistency feasible for dryland preparation will take longer time, thus, shortening crop growing period for non-rice crop. In addition, planting non-rice crops to previously puddled soils will require subsoiling to provide roots with larger soil volume to extract moisture and air. The plow pan, 25 cm deep (De Datta, 1981), should be destroyed.

Climatic pattern. Ideally, rice irrigation systems should be constructed only in regions with uneven rainfall distribution. Irrigation systems stabilize water supplies and thus increase production. But since rice is susceptible to water deficits, irrigation systems have been constructed even in places where rainfall is uniformly distributed.

Farmers in irrigated areas under uniform rainfall distribution (e.g., Philippine rainfall types II and IV) prefer monoculture rice system to diversified cropping system (IIMI, 1986; IIMI, 1987b; Paris and Jayasuriya, 1982) (Figure 3). They perceive even limited water supply as sufficient in satisfying rice water requirements. Farmers simply reduce their planted areas to avert risks from eventual drought. Paris et al. (1982) reported that monoculture rice system dominates irrigated places receiving more than 100 mm of rain per month.

Table 2. Potential of different soil textures puddled to different degrees under limited and adequate water supply.

		Soil texture			
	2:1 clay	Sandy loam	Silt loam	Clay loam	Clay
	1:1 clay	Silt loam	Clay loam	Clay	
		Percentage increase in bulk density by puddling			
		<4	4-8	8-12	>12
Crop	Water supply	Crop potential after rice			
Peanut	Limited	Good	Intermediate	Poor	Poor
	Adequate	Good	Good	Intermediate	Poor
Maize	Limited	Good	Intermediate	Poor	Poor
	Adequate	Good	Good	Intermediate	Poor
Sorghum	Limited	Good	Good	Intermediate	Poor
	Adequate	Good	Good	Good	Intermediate
Soybean	Limited	Good	Good	Good	Intermediate
	Adequate	Good	Good	Good	Good
Mungbean	Limited	Good	Good	Good	Intermediate
	Adequate	Good	Good	Good	Good
Cowpea	Limited	Good	Good	Good	Good
	Adequate	Good	Good	Good	Good

[6]Soil bulk density is the ratio of a mass of soil to its volume. It indicates the degree of compactness or looseness of the soil.

CLIMATIC ZONES OF THE PHILIPPINES

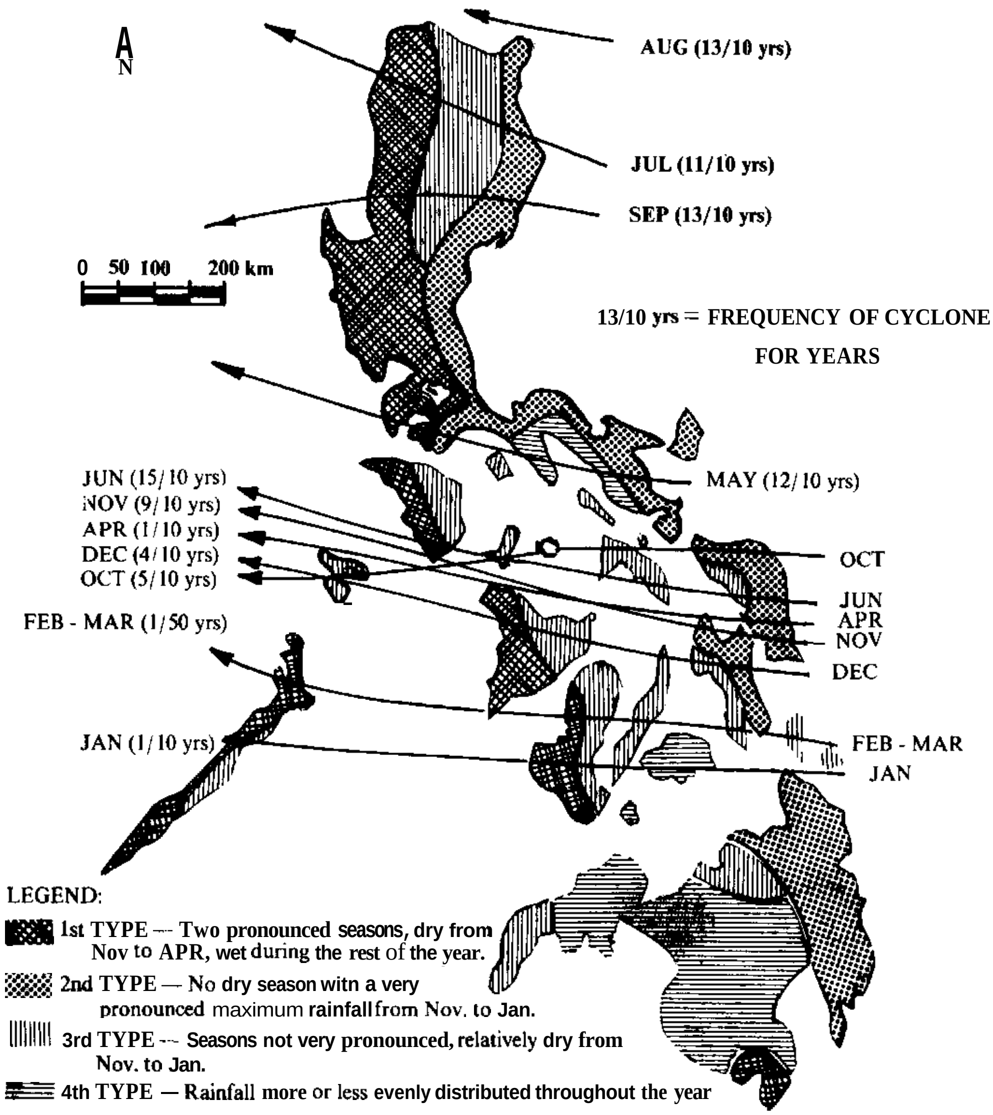

Figure **3. Climatic map** of the **Philippines.**

On the other hand, irrigated-rice farmers under unimodal rainfall distribution will either diversify into non-rice crops or fallow their lands, depending on water supply reliability and soil suitability. Today, more successful crop diversification occurs in irrigated rice systems with well-drained soils under unimodal rainfall distribution.

Operational properties. Although many rice-based irrigation systems experience limited water supplies, they cannot be expected to diversify into non-rice crops. Literature show that limited system water supply is insufficient to encourage irrigation personnel to veer away from monoculture rice system. Only when mandated, pressured or are encouraged to spread limited water supplies to a larger area will irrigation personnel diversify into non-rice crops.

Presently, crop diversification in a few irrigation systems is almost entirely farmerdriven. Irrigation personnel plan and implement rice-based operation scheme and let farmers decide to either diversify into non-rice crops, or continue with monoculture rice. With this strategy, irrigation personnel run the main parts of the irrigation system based on rice, while farmers diversify into non-rice crops. The diversifying farmers contribute a lot to main system operations to meet requirements for non-rice crop irrigation.

Some rice-specific irrigation systems, though, draw operation schemes for dry season mixed cropping. Rice is set for areas with heavy soils and adequate water and non-rice crops for areas with light soils and limited or unreliable water supply.

Rice can be irrigated by either continuous shallow water delivery or by rotational or intermittent delivery, depending on the availability of water. Non-rice crops, however, can be irrigated only by rotational or intermittent water delivery regardless of the availability of water.

Irrigation personnel will most likely avoid allocating and distributing limited water supplies to avoid high-intensity-input management. Reserved management resources to enable them carry through water crisis management are nonexistent. To avoid risking their credibility with uncertain outcomes of water deficit management, irrigation personnel reduce the size of service area commensurate with available water supplies, then plant rice instead of non-rice crops. Clearly, they are unprepared yet to run irrigation systems, at variance with the original operation scheme.'

Structural Capacities and Capabilities

The structural capacities and capabilities of most rice-based irrigation systems may be inadequate for irrigating non-rice crops. Keeping rice soils continuously flooded requires low structural capacities and capabilities. Continuous delivery of water at low flow rates in the main parts of the system and field-to-field water application are adequate to maintain rice under favorable water conditions. Due to low water flow rates, the carrying-capacity of rice conveyance system is low.

Generally, rice conveyance system can carry 1.5 liters per second per hectare (lps/ha). This is much lower than the observed canal-carrying capacity required for non-rice crops which is 2.5 lps/ha in one system in South Cotabato, Philippines (IIMI, 1986). Accumulated over a long irrigation interval and delivered at one shot, the irrigation demands of non-rice crops are higher than those of rice.

Aside from increased canal capacity, rice-based irrigation systems should upgrade their structural capabilities to irrigate non-rice crops. Uncontrolled water releases are not detrimetal to rice but are hazardous to dryland crops. Non-rice crops are intolerant to saturated soil even for a short period.

For main canal regulation, this intolerance suggests controlled releases of high water flow rates into farm turnouts to meet high irrigation demands and prevent waterlogging. Hydraulic bead, higher than that required for irrigating rice must be built up at the parent canals to produce high water flow rates into farm turnouts. Thus, system's reserved capacities, specifically canal freeboard, should be utilized to produce the higher hydraulic head.

But even simple reserved capacity as canal freeboard might be absent in many rice-based irrigation systems. Many irrigation systems have much reduced (structural control) capacities due to poor state of disrepair. Thus, to increase rice-based irrigation systems' flexibility for non-rice crops will call for improvement of system structural capacities and capabilities.

'Whether irrigating rice or non-rice crops, rice-based irrigation systems in Asia are operated with a minimum relative water supply equal to 1.4. This means that irrigation must be supplied 40% more than the field water requirement. See Moya and Walter, (1988).

The following structural constraints in irrigated rice-based systems must be considered when promoting irrigated crop diversification.

Canal configuration. Irrigation systems that have been designed based on continuous water delivery have a conveyance system of tapered canal configuration, i.e., the canals have gradually decreasing cross section from head to tail. **Correspondingly**, the system's canal carrying-capacity decreases from head to tail. Axiomatically, crop diversification potential decreases from head to tail of rice-based irrigation systems. In effect, the productivity and equity benefits from crop diversification decreases from head to tail of rice-specific irrigation systems.

Tailend farmers can plant a postmonsoon crop only when the residual soil moisture is adequate or other water sources can be tapped (e.g., shallow wells). Distance from main water source, limited structural capacities and capabilities, and lack of dry season water supply, will all combine to demand extra management efforts on irrigation personnel for bringing water to tailend farmers. However, irrigation personnel are unable or unwilling to meet these high demands. Thus, tailend farmers have slim chances of cultivating even non-rice crops during the dry season if they would depend solely on system water supplies.

Deep canal. Aside from being tapered, canals of most rice-based irrigation systems on large flat plains are also deep-cut, i.e., canal bed is lower than field elevation. Deep-cut canals with moderate structural capabilities are sufficient for continuous shallow irrigation. but inadequate for short-duration, high-flow-rate irrigation of non-rice crops. High-flow-rate at the turnouts requires sufficient hydraulic head at the parent canals to push water into level rice basins fast enough to avoid waterlogging. Filling deep-cut canals to the brim to build sufficient hydraulic head will entail structural supports. Otherwise, high water losses will ensue!

Much water will remain in deep-cut canals after a shortduration, high-flow-rate irrigation, and will contribute to canal dead storage. Irrigating non-rice crops can be **as** inefficient **as** irrigating rice. Cutback or surge irrigation minimizes water application losses in the fields, but does not necessarily reduces canal dead storage losses.

Impounding residual water in canals can minimize waterlogging, at the same time, **serve as** buffer **or** temporary **storage**.[9] The impounded water can be used to minimize water supply variability or to fully supply rice water requirements in topographically lower sections. Water level in the impoundments creates natural hydraulic head sufficient for continuous shallow irrigation. Should topography limit the distribution of impounded water by gravity, conjunctive **use of** buffer storage and pumping can **be** explored. Apparently, without complementary measures to avert water losses, the water savings from non-rice crop cultivation in irrigated rice systems will not materialize.

Technical-operational compromise. In spite of soil limitations and system structural deficiency, some irrigated-rice farmers can diversify into non-rice crops, provided markets are favorable. Irrigation personnel employ ad *hoc* system operation procedures, while farmers *experiment* with irrigation and crop cultivation practices.

Limited systems' water supply for non-rice crops can be distributed in two ways: (1) concentrate water supply into smaller fraction of the service area to accumulate sufficient hydraulic energy for shortduration, high-flow-rate water application, or **(2)** spread limited systems' water supply to larger service area and employ short-duration, low-flow-rate water applications. The **first** option indicates a need for upgraded system structural capabilities aside from organizational capabilities, whereas the second option implies organizational capabilities. Either option, however, requires high structural and organizational control because systems' water supply **is** limited and has to be rotated (Levine **et** al, 1976).

Furthermore, the productivity and equity objectives of irrigation systems limits the choice between these two options. Higher water productivity follows from the first option; higher equity from the second option.

The efforts irrigation personnel expend to complement the system's structural deficiency are supplemented by fanners' efforts to enable non-rice crop diversification, resulting in many farm level concerns in crop diversification.

Farm *level concerns*. With regard to on-farm water regulation, drainage facilities, much better

[8]Dead storage is the amount of water which is left in the canal after irrigation has been temporary withheld.

[9]Ponding losses attributable to S&P and evaporation will occur but they will be relatively smaller compared to losing altogether the residual water to nonproductive dead storage losses at the same time.

than those for rice are needed because of the inability of non-rice crops to tolerate excessive moisture. Similarly, sufficient on-farm water supply facilities are required for irrigating non-rice crops in level rice basins to allow high-flow-rate irrigation, and avoid waterlogging. However, rice irrigation ordinarily involves neither water removal network nor water supply network in the field as rice tolerates moderate flooding.

Further complication from intolerance to waterlogged conditions arises from non-rice crops' deep rooting systems (FAO, 1986). Unless adequate drainage facilities are provided, non-rice crops cannot be successfully cultivated in rice-based irrigation systems.[10]

Since adequate drainage facilities are not commonly available in rice-specific systems, farmers plant non-rice crops only in welldrained soils.

In some occasions, landforming or landshaping are undertaken in addition to providing drainage facilities. In Japan and the People's Republic of China, shurt growing season and high population density pose as constraints in modernizing their irrigation systems. Intensive on-farm irrigation and drainage facilities have been installed by the Japanese and Chinese in their irrigation systems. Well and subsurface drainage enables rice farmers in China to plant second crop of wheat or other non-rice crops (Soong and Wei, 1985). Likewise, most irrigated-rice systems in Japan include subsurface drainage facilities to speed up soil drying for mechanized harvesting and land preparation (Tabauchi, 1985).

But for rice-based irrigation systems with lower drainage capabilities than those in Japan and the People's Republic of China, arudimentaryand temporary surface removal network, together with sloped furrow or border irrigation methods, may be sufficient to meet the drainage requirements of non-rice crops." However, conventional graded furrow or border irrigation is impractical in flat lands without landshaping or landgrading. A minimum threshold field grade is needed for efficient and uniform water application by either furrow or border irrigation.

Landforming or landshaping may also involve subsoiling (deep tillage) or raising beds to increase volume of aerated soil. Hard pans impede root growth and development. Therefore, breaking hardpan should increase depth of aerated soils (Yoshida, 1981; Kramer, 1983). Extrasoil aeration can also be produced by lowering the water table.

Consequently, farmers end up using heavy machinery as animal draft power will be insufficient for landshaping and landgrading if a farmer plants more than a hectare of non-rice crops." Heavy tractors, however, destroy paddy bunds and weigh down or break plow pans. Broken or sunken plow pans increases soil drainage and aggravates water losses from succeeding flooded rice cultivation.

Furthermore, temporarily graded fields previously planted to non-rice crops must be levelled back to distribute water evenly within the rice basins. Sunken or broken hard pans and the lopped paddy bunds must be restored to control water outflow from ricefields.

Reconstructing paddy bunds and recreating hard pans require a lot labor. It also take sometime to mend a broken pan and to produce a watertight bund, hence large S&P losses will occur from fresh pans and bunds during land preparation for rice. Collectively, breaking and mending of hard pans, lopping and building of paddy bunds, and field grading and levelling result in a vicious problematic cycle for wet season-rice:dry season-non-rice cropping pattern in irrigated systems. The cycle can create both economic and technical disincentives to dissuade irrigated-rice farmers from diversifying into non-rice crops.

How do diversified farmers contend with these physical and technical limitations?

Farmers who diversify their cropping pattern can cope up with these limitations by first, Limiting non-rice crops to a small fraction of their farmholding of welldrained soils. For instance, farmers under the Upper Talavera River Irrigation System

[10]In addition to drainage facilities, sufficient supply should also be provided to distribute water at a rate fast enough to effect waterlogging of level basins planted to rice.

"As discussed elsewhere, farmers select crops that can be irrigated by techniques that either closely approximates flooding for rice or modify the conventional border and furrow irrigation techniques, such as the *inverted* border irrigation.

[12]Moya and Murray-Rust (1985) observed that almost all farmers who received water from P-27 deepwell pump system in Guimha, Nueva Ecija, Philippines and who planted at least a hectare to non-rice crops, either corn or peanut, following the wetseasonricecrop, resorted to landforming and landgrading using heavy machinery to cut turnaround lime

(UTRIS) and Laoag-Vintai River Irrigation System (LVRIS) plant onion and garlic to only 1,000-1,200 m^2 (IIMI, 1988; Bumanlag, 1988). Second, by selecting shallow- or medium-rooted non-rice crops, which can be irrigated by flooding. This ad hoc measure may partly explain the choice of a rice-onion and rice-garlic pattern by UTRIS and LVRIS fanners, respectively.[13] Third, some farmers dry seed their wet season rice in plots intended for dry season non-rice crops. They may also seed their wet season rice in dry and compacted soils rather than in puddled soils (Ghildyal, 1978). Other tillage practices for wetland rice, such as zero and minimum tillage, are also practiced when appropriate (De Datta and Barker, 1978). Fourth, if attempts to break or circumvent the vicious cycle entails prohibitive costs, some farmers just fallow their lands during the dry season.

In summary, because rice and non-rice crops basically differ in physiological and agronomic characteristics, they grow and produce best in contrasting soil-water environments. Consequently, they require contrasting water management strategies.

Continuous water distribution is adequate for rice, but rotational or intermittent irrigation is a must for non-rice crops. A skeletal water distribution and removal network is enough for rice irrigation while a more complete water distribution and application network, coupled with drainage network is a must for non-rice crop irrigation.

To satisfy non-rice crop's drainage requirements, diversifying farmers may end up using heavy machinery. Heavy machinery destroys paddy hunds and plow pans, thus increasing water and nutrient losses from flooded ricefields through leaching. Converting ricefields to non-rice crop fields creates a vicious cycle of technical and management problems for farmers and irrigation personnel. Presently, farmers and irrigation personnel skirt around the vicious cycle through a number of ad hoc measures. Basic soil-water and irrigation management research should backstop farmers and irrigation personnel directly to break into the vicious cycle.

For example, **it** is important to consider an optimal percentage of the total service area with **soil** properties that are suitable for non-rice crops before a diversified crop imgation system is designed. Constructing irrigation systems on light and porous **soils, as** well as on heavy and less pervious soils must he carried through only after a rigorous technical and economic analysis had confirmed the feasibility. The savings in water expected from low water use by diversified crops on light soils may be offset by high conveyance losses, or by the high costs of lining conveyance system to rule out water losses. Similarly, the high costs of providing drainage facilities to non-rice crops on heavy soils may offset the expected water savings.

Climatic pattern prevailing in irrigation systems that will be operated, rehabilitated or constructed to allow crop diversification should also be considered. Rainfall distribution greatly affects soil moisture and aeration capacity, which in turn, affect cropping sequence. Farmers in areas with unimodal rainfall pattern have more incentives to diversify than farmers in areas with uniform rainfall distribution. In areas with unimodal **rain**fall distribution, the soil is aerated part of the year, while in areas with uniform rainfall distribution, the soil is saturated most of the year.

From the operational point of view, imgation field personnel will veer out of monoculture rice systems to increase productivity and equity of limited water supply only when mandated, pressured or encouraged to do **so.** Otherwise, these personnel will just reduce their service area and program the area for rice **so** as to avoid high-intensity-input management. The resource capacities found in many rice-based systems cannot meet the high operational control needed for crop diversifcation.

Design of new diversified crop irrigation systems or rehabilitation of old rice-based systems to accommodate non-rice crops should pay attention to these technical issues. Important, economic, institutional and social issues to crop diversification should be also accounted for towards a more comprehensive understanding of diversified cropping.

Economic Issues

In evaluating benefits and costs of water savings expected from **non-rice** crop cultivation,

[13]Onions and garlic have a maximum effective rooting depth of 30 cm. In comparison, peanut has a maximum effective rooting depth of 80 cm; corn, 100 cm; and tomato, 100 cm. The rooting depth of garlic and onions approximates that of rice, which is about 20 cm. See FAO (1986), Yoshida (1978) and O»Toole, el al. (1978).

two economic issues must be accounted for. First, as non-rice crops will be cultivated on porous soils, the expected benefits of savings in water from crop diversification can be offset by either high water losses in the conveyance system or high costs of canal lining to minimize these losses. Second, the costs of high operations control needed for irrigating non-rice crops should be compared with the value of benefits derived from increase in production.

Other economic issues revolve around the profitability of cultivating non-rice crops compared to rice. Improved rice technologies have sufficiently increased rice productivity which caused a major rise in world food supply. This, in turn, caused a decline in the price of grains in the world market. Eventually the global price decline renders rice farming less profitable than before. Hence, rice farmers must look for other ventures that can increase their incomes; an alternative is to veer out of rice monoculture and plant high value, low water-requiring non-rice crops.

Most rice-producing countries have comparative advantage in non-rice crop production, such as corn, soybean and mungbean. These countries spend large fraction of their foreign exchange earnings on imports of non-rice feedgrains. Governments therefore, have large economic incentives to encourage local production of non-rice crops. From economics point of view, non-rice crops grown locally can still be profitable.

However, at the local level, markets for non-rice crops are not established, so their prices are unstable. The price ratio of rice:non-rice is usually bigbenough to induce farmers to grow rice rather than non-rice crops. The price ratio affects water productivity of rice and non-rice crops, too. Moya and Murray-Rust **(1985)** compared water productivity for rice and corn at **P-27,** a deep **tubewell** irrigation system in Nueva Ecija, Philippines, in terms of value of output per cubic meter of water supplied **(₱/m^3)** (Figure 2). Water productivity for corn, in terms of yield per cubic meter of water was about three times that for rice, but since corn price was one-third of that for rice, water productivity for corn, in terms of pesos per cubic meter of water does not differ from that for rice. Therefore, prices for non-rice crops have to be competitive enough to create water productivity incentives fornon-rice crop cultivation.

Growing non-rice crops entails higher production costs per hectare than rice because of higher inputs, especially labor and chemical (IIMI, **1986;** IIMI, **1988).** In most developing countries however, inputs are not readily available prompting farmers to use inputs at suboptimal levels resulting in low yields. Considering further that price of non-rice crops fluctuates widely in local markets coupled with inadequate production inputs, a farmer's profit from non-rice crop production is less and more variable than profit derived from rice. Thus, there must be enough economic incentives to encourage rice farmers to diversify into non-rice crops.

Input subsidy, guaranteed markets and higher price for output have been found to induce fanners to plant non-rice crops. For instance, most rice farmers in the Gal Oya Imgation scheme in Sri Lanka shifted to cultivating chili during the **1979** dry season when the government guaranteed higher price for chili than for rice. **A** similar case has been observed in farmers' adoption of diversified cropping in the Kemubu Imgation, a pump irrigation scheme in Malaysia (Ng, **1976).** There were great cost-cutting incentives to adopt crop diversification in this system. The government subsidized production inputs and guaranteed markets and higher prices of non-rice crops to encourage Malaysian farmers in sections of command area with suitable soil to cultivate tobacco and peanut. Moreover, the government assured each diversifying farmer with 1000 kg of rice to cover the basic family rice consumption. Taiwan has also instituted a diversification scheme similar to that of Malaysia. These economic incentives, in a way were created to cover-up for the risks involved in non-rice crop production technologies.

However, the incentive-creating process entails costs and a financially strapped government will be unable to sustain the giving of these incentives for a long time. Fanners will thus remain in status quo that is, they will rather reduce their area to be planted to rice than expand it through diversified cropping.

Social and Institutional Issues

Institutional issues will inhere from potential technological or economic disequilibrium concomitant with crop diversification. First, government and research institutions might be induced to supply, through cooperative efforts, additional information to bridge any knowledge gap on diversified cropping. Second, to alleviate the constraints imposed by the unavailability of production inputs, the government might supply low interest credits to diversifying farmers. More importantly, institutional issues might be expected from changes in water allocation and distribution rules to accommodate soil-water requirements of upland crops. Irrigation service fee payment could be also a significant institutional issue for diversified cropping.

With regard to social issues, fanner's water-related behavior and attitudes toward changes to be brought about by diversified cropping technologies might be consequential. Changes in communication pattern might be expected since non-rice crops would be cultivated under tight water supplies and better means of communication and coordination will be important. Farmer participation might also be a social issue for crop diversification.

Conclusions

Important technical, economic, institutional and social issues in diversifying rice-based irrigation systems have been presented. Issues on crop-soil-water environment, climatic pattern and on physical and operational control capacity of rice-based irrigation systems are the basic technical considerations in crop diversification. Soil-water related issues focus on soil aeration.

With respect to climate, diversified rice-based systems can be constructed in areas with unimodal rainfall distribution. In areas with uniform rainfall distribution, fanners will insist on growing rice.

The increased physical and operational control required to accommodate non-rice crops *may* be beyond the resource capabilities of *many* rice-based irrigation systems. These systems *may* lack physical control facilities and structures to effect rotational or intermittent irrigation. Excess management capacities do not *usually* exist for high-intensity-input operations to deal with limited water supplies. Moreover, on-farm facilities needed to produce the level of control for appropriate diversified crop irrigation techniques are *mostly* lacking.

A major economic issue is the assessment of cost of water expected to be saved from crop diversification in relation to projected benefits From increased production. The relative price of rice:non-rice crops is an important indicator. Water productivity for rice and non-rice crops depends upon this relative price. Input subsidy, higher prices, and guaranteed markets for non-rice crops have been found by previous studies to induce short-term diversilication.

Anticipated changes in water allocation and distribution rules to accommodate changes in soil-water conditions for non-rice crops might be significant institutional issues. Moreover, the willingness of government and research institutions to bridge the knowledge gap on non-rice crop cultivation could be counted important. Likewise, farmer attitudes and behavior toward expected changes in water allocation and distribution rules might be significant social concerns. Issues on improved communication and coordination relating to diversified cropping should be also dealt with.

Technical, economic, institutional and social issues which are expected to be consequential to crop diversification have been presented in this paper. Each issue can uniquely influence crop diversification, but interactions among these issues will contribute to a broad understanding of factors that drive irrigated crop diversification.

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Irrigation Management for Diversified Crops: Opportunities for Learning and Improvement

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Abstract

The interim results of the study as conducted by the International Irrigation Management Institute (IIMI) is presented. Existing practices of farmers and the National Irrigation Administration (NIA) personnel in managing the available water supply are highlighted. These practices were analyzed for possible adoption in other NIA systems. The paper also presents opportunities for improvement to optimize land and water use during the dry season.

Limited water supply and suitable soils were the main physical factors that enabled farmers to effectively irrigate rice and non-rice crops during the dry season. The active involvement of the irrigators' association (IAs) in water allocation and distribution resulted in optimal or effective *use* of limited water supply. Further investigations into other factors, like the rice priority policy and other socio-economic incentives that will make irrigated crop diversification attractive and profitable to farmers were suggested.

Introduction

For the past **20** years, technological change has resulted in a gradual increase in the value of irrigation during the dry season. The main reason for this shift was the adoption of modern rice varieties whose yield potential **is** much higher during the dry season than during the wet season. The economic viabilities of farming and investments in irrigation systems are becoming more dependent on dry season cultivation. **As** a result, competition for limited water supply during the dry season has increased.

However, once self-sufficiency in rice **is** attained, there would be a comparative advantage in growing non-rice crops in irrigated areas during the dry season **(IFPRI,** 1984). Moreover, growing of irrigated non-rice crops during the dry season would also optimize the use of water and land which are ***not*** enough to support rice production. It takes almost twice as much water per hectare to grow rice than upland crops at the farm level. In some rice-based irrigation systems with limited water supply, the prevailing practice **is** to grow rice and non-rice crops during the dry season.

Practices and procedures in the production of irrigated non-rice crops have evolved through the years. However, it is only at the farm level where a headway was made in terms ofestablished practices (PCARRD-IIMI, 1988). Although there **is** a potential to increase production in irrigated areas during the dry season, factors that contribute to the success of growing non-rice crops have not been fully understood. Moreover, there are no established guidelines or procedures in irrigation management[2] of existing irrigation systems where mixed cropping is practiced during the dry season. This paper presents the interim results of a study' conducted by the International Irrigation Management Institute (IIMI). It determined irrigation management for mixed cropping **as** well **as** identified learning experiences and opportunities to

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'Irrigation management in this paper refers to the operation of the irrigation system to meet the objective of effectively providing adequate and timely water for optimum crop growth. Aside from water, other system components have to be managed including *information*, human *resources (farmers*, NIA *personnel, etc.,) and other inputs in crop production* revolving around water and its control (Keller, 1988).

[3]The results presented in this paper were taken from the Interim Report, Study on Irrigation Management for Diversified Crops, September 1988. Thin study was primarily supported by a grant from the Asian Development Rank (ADB) to the Goverment of the Philippines as TA No. 859.

improve these practices. The study was undertaken in collaboration with the National Irrigation Administration (NIA), Central Luzon State University **(CLSU),** Mariano Marcos State University (MMSU), University of Southern Mindanao (USM), Pampanga Agricultural College (PAC), University of the Philippines at **Los** Baños (UPLB) and the Department of Agriculture (DA).

The study sites were: the Laoag Vintar River Irrigation System (LVRIS) and the Bonga River Pump No. **2** Irrigation System (BP#2) in llocos Norte; the Upper Talavera River Irrigation System (IJTRIS) in Nueva Ecija; and the Allah River Irrigation Project (ARIP) and Banga River Irrigation System (BARIS) in South Cotabato.

Prevailing Irrigation Management Practices

Cropping Systems. Two main **sources of** irrigation water are available, in the study sites: rainfall and river flow. Shallow wells are used only for supplementary irrigation. Ilocos Norte and Nueva Ecija have similar rainfall (Figure I). The main crop or first crop is grown during the rainy months (May to September) and the second crop during the dry months (October to April). Rice **is** the main crop and a variety of crops follows.

In South Cotabato, rainfallis relatively evenly distributed throughout the year; with larger amounts from May to October and **lesser** during

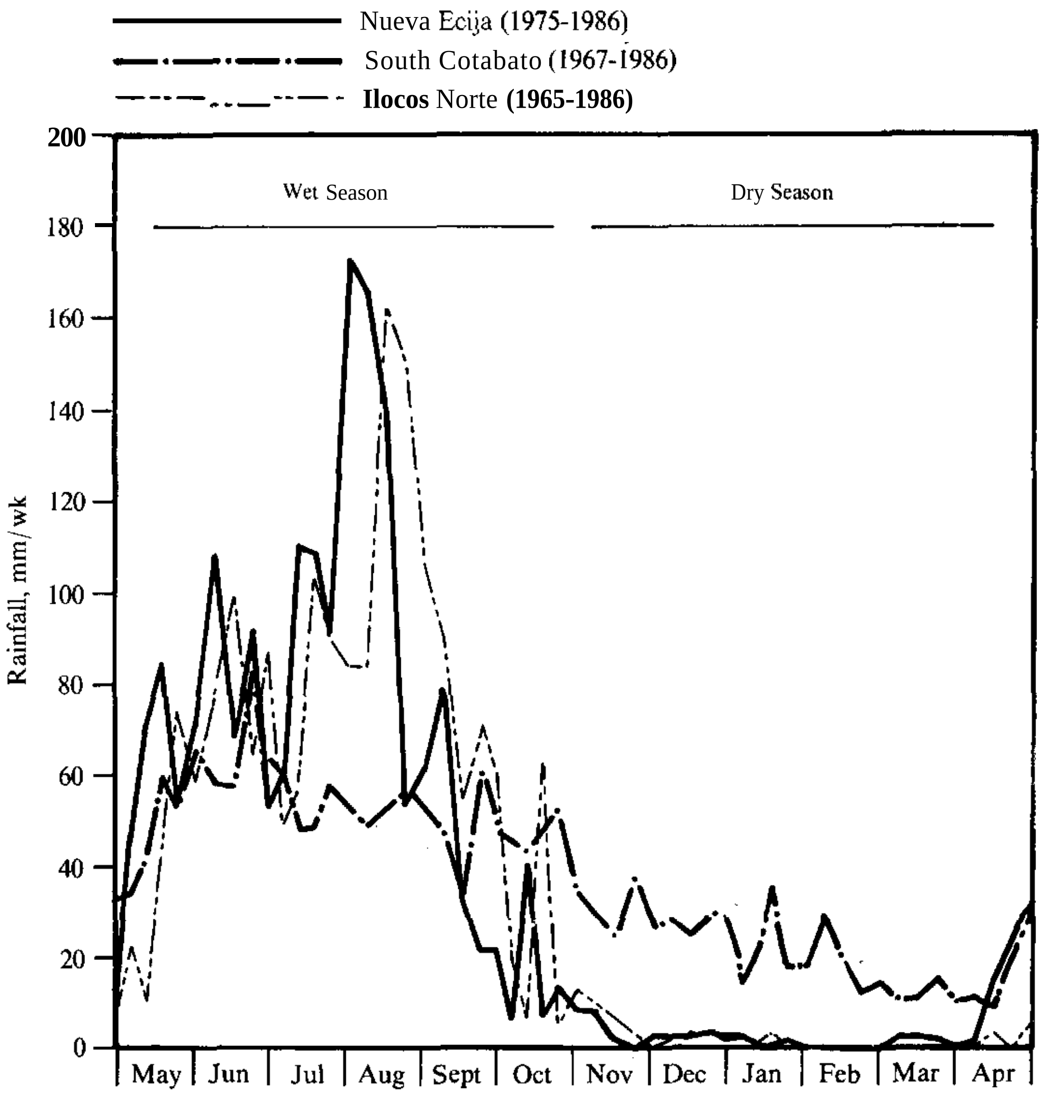

Figure 1. Mean Weekly Rainfall, South Cotabato, Nueva Ecija, & Ilocos Norte, Philippines.

the rest of the year (Figure 1). The main crop is grown during the rainy months while the second crop is grown when there is less rainfall, i.e., from November to March. Farmers especially in rainfed areas follow other cropping patterns. With abundant ranfall, mixed cropping is practiced during the dry and wet seasons. The main crops grown are rice and corn. Rice is usually irrigated during the dry season.

The limited water supply during the dry season resulted in less irrigated area in all of the sites than during the wet season (Table I). Thus farmers practiced mixed cropping pattern. Limited water supply appears to be a necessary physical condition which makes irrigated diversified cropping persistent during the dry seasons.

Table *1*. Irrigated areas and percent reduction in area served, crop year 1987188.

Location	Wet Season (ha)	Dry Season (ha)	Percent Reduction[1]
LVRIS	2220	1456	66
BP#2	375	213	57
UTRIS	3616	1395	38
ARIP	4668	3038	65
BARIS	1930	1750	91

[1] $\frac{\text{Wet Season Area} - \text{Dry Season Area}}{\text{Wet Season Area}} \times 100\%$

Water *Allocation.* At the onset of each cropping season, the irrigators' associations (IAs) and NIA meet to discuss the program area and water delivery schedules. The degree of farmers' participation depends on the level of involvement and functionality of the different IAs. Among the sites studied, the IAs under BARIS were found to have been very much involved and committed to the equitable sharing of water during the dry season.

Areas programmed for rice during the dry season were rotated on a yearly basis giving equal opportunities for all areas to be irrigated. Farmers in areas not programmed for rice were encouraged to plant corn and other upland crops. These areas were irrigated upon the farmers' request, a procedure needed to facilitate collection of irrigation fees. However, priority was given to areas programmed for rice.

Under LVRIS, the locationally favored (upstream) VINTAR IA was not interested in equitable sharing of water, especially during the dry season. Thus, only the LABASA IA was involved in water allocation activities. Areas near canals and those located at lower elevations are programmed for rice. Areas programmed for non-rice crops were located at the tail end of lateral and sub-lateral canals. Areas with coarse textured soil (as in some portions of Division I) were also programmed for non-rice crops. A third crop of mungbean was usually programmed, depending on the available water at the end of the dry season. Usually, two to four deliveries are available after the regular second crop.

Since BP#2 was partially turned over to the IA with no direct intervention from NIA, water allocation was simpler. Notwithstanding this arrangement, not all areas were irrigated for rice due to limited water supply. Farm location, soil suitability, and farmers' promptness to pay irrigation fees were the criteria used in allocating water for rice farms during the dry season. Non-rice crops, mostly garlic and watermelon, were also programmed.

At UTRIS, only upstream IAs were involved in water allocation. Nominal participation of other IAs are observed but farmers did not participate in actual group work activities or attend meetings. Farmers from the upstream IAs were found to be uncooperative resulting in the difficulties encountered in water allocation at the start of the season. Farmers were given the option to plant the crop of their choice. The NIA personnel, however, cautioned farmers that water was sufficient only in areas near the source. As a result, non-rice crops (mostly onions) were not programmed. Only rice areas were programmed for irrigation. Areas planted to rice and non-rice crops were billed accordingly. Under UTRIS, areas with medium textured soils which were located at the upper and middle portions of the service area wefe planted to non-rice crops.

Under ARIP, participation of the IAs in water allocation was at its early stage. The IAs of laterals A, B and C-extra were not convinced that their areas should be programmed for non-rice crops during the dry season. Most farmers in these areas preferred to plant rice even without being assured of irrigation water during the dry season. They thought that irrigation was synonymous to irrigated rice production because of the seeming abundance of irrigation water in irrigation canals and occassional rainfall during the dry season.

Water Disiribuiion. In all sites, a continuous method of water delivery was used for rice areas during the wet and dry seasons. However, water was delivered on a rotational schedule when supply became scarce. In the rotational schedule, irrigation of non-rice crops was included but priority was given to rice. For upland crops, an intermittent method of irrigation **or *flushing*** was applied.

During the **1987** wet season water was adequately supplied at LVRIS (Tables 2 and **3).** Water diverted to Division I was more than twice the amount diverted to the other three divisions downstream. Nonetheless, all the areas planted received adequate water supply. There was no cut-off of irrigation water delivery between the wet and dry seasons. During the dry season, a total of **1,456** hectares were irrigated consisting of **930** hectares planted to lowland rice and **536** hectares **(37%** of total area) planted to upland crops, mostly garlic. Rice was planted in Division I (laterals A to E) while the non-rice crops were planted downstream (Figure **2).** There was abundant water supply at the start of the dry season (Table **4)** because of residual river flow from a previous typhoon. Continuous deliveries, especially for rice areas, were made from November until mid-February. On the third week of February, a rotational schedule was implemented due to the abrupt decline in water supply from the river. Upstreamfarmers, however, did not follow the rotational schedule resulting in delayed and irregular water deliveries to the tail portions of the laterals. Unequal distribution of water occured because upstream fanners exceeded their schedule and because of the priority given to irrigating rice. However, estimated water use efficiency (WUE) indicated better distribution during the dry season (Table **2).** Moreover, there was no reduction in yield due to moisture deficit (Table 5).

At BP#2, only **58** hectares **(27%** of total area) out of **2 I3** hectares programmed for tne dry season were planted to non-rice crops. Other farmers within the service area planted non-rice crops using their own shallow pumps. The estimated WUE was **78%.** Lined canals and careful application of water contributed to the high WUE which was higher than at LVRIS (Table **7).**

At UTRIS, the **1987** wet season crop was delayed due to late rainfall. Downstream farmers who planted in June and July, augmented irrigation water by using shallow pumps. Adequate rainfall started in August when the monthly total rainfall exceeded **50** mm. Total area planted was **3,629** hectares. Estimated WUE **was** 53% (Table **8).**

During the **1987/88** dry season, a larger area was irrigated compared with the previous dry season. The total area irrigated was **927** hectares. Around ***465*** hectares (50% of the total **area)** were planted to non-rice crops, mostly onion. However, theestimated area planted exceeded I,000 hectares. Areas with suitable soil were planted to non-rice crops (Figure **3).** Farmers in areas that were not programmed for irrigation took advantage of the seemingly abundant water supply in November and December and planted a second crop of rice. Water supply abruptly decreased in January resulting in its scarcity especially downstream. Shallow tubewells were again used to augment the limited water supply.

To enable all programmed areas to receive water, a rotational schedule was developed and was agreed upon during a meeting between NIA and the IA. However, this schedule was violated because some farmers diverted water to their fields even if it was not their turn. This usually happened during the night. Laxity of NIA field personnel in enforcing the schedule and lack of or poor state of control gates and structures aggravated the situation. Furthermore, scarcity of water **was** also attributed to the existence of a makeshift dam upstream (about 2-km from UTRIS dam) to irrigate approximately 60 hectares of onions. The resulting water scarcity contributed to the high WUE of **72%** for the system (Table **9).**

AT ARIP and BARIS, irrigated crop diversification was not an accepted practice. At ARIP, the total area irrigated was 3,100 hectares during the 1987/88 dry season. The WUE was **42, 37** and 57%, for the upstream, midstream and downstream sections, respectively (Table 10). Use of drainage water from the upper sections by the downstream section, although not measured, contributed to this uneven distribution.

Suitable soil for non-rice crop were concentrated in laterals A, B, and C-extras (Figure **4).** These areas were programmed for non-rice crops and were intermittently irrigated by ***flushing.*** Before the 1988/**89** dry season, farmers from these areas were advised to plant non-rice crops. However, only farmers at lateral A-extra planted irrigated non-rice crops. Farmers a? laterals Band C-extras were more concerned on when to plant corn because their rice crop was harvested in September and if they were to plant corn in

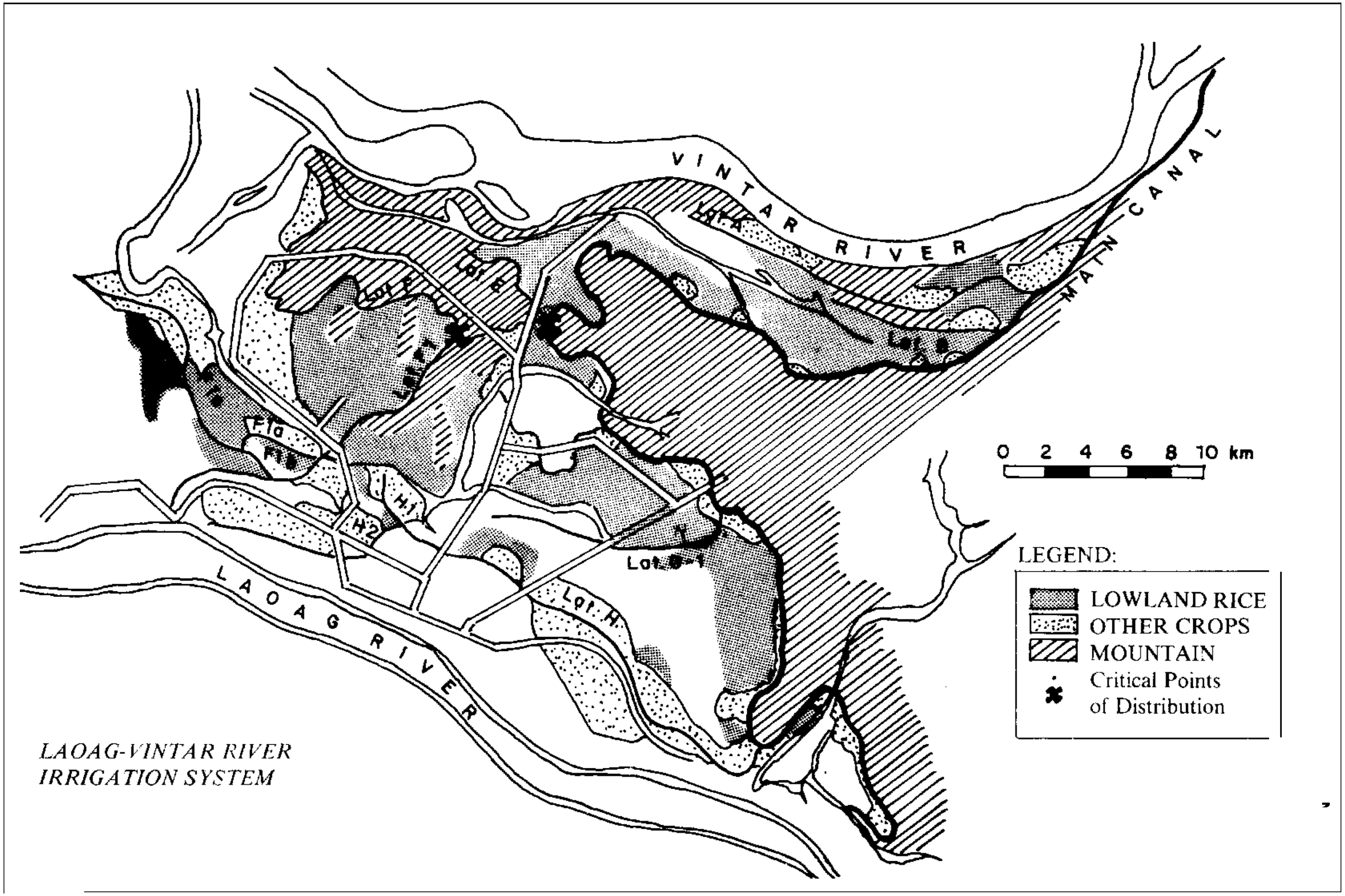

Figure 2. Map of the Laoag-Vintar River Irrigation System (LVRIS) in Ilocos Norte showing cropped **areas** for 1987/88 dry season and critical points **of** water distribution.

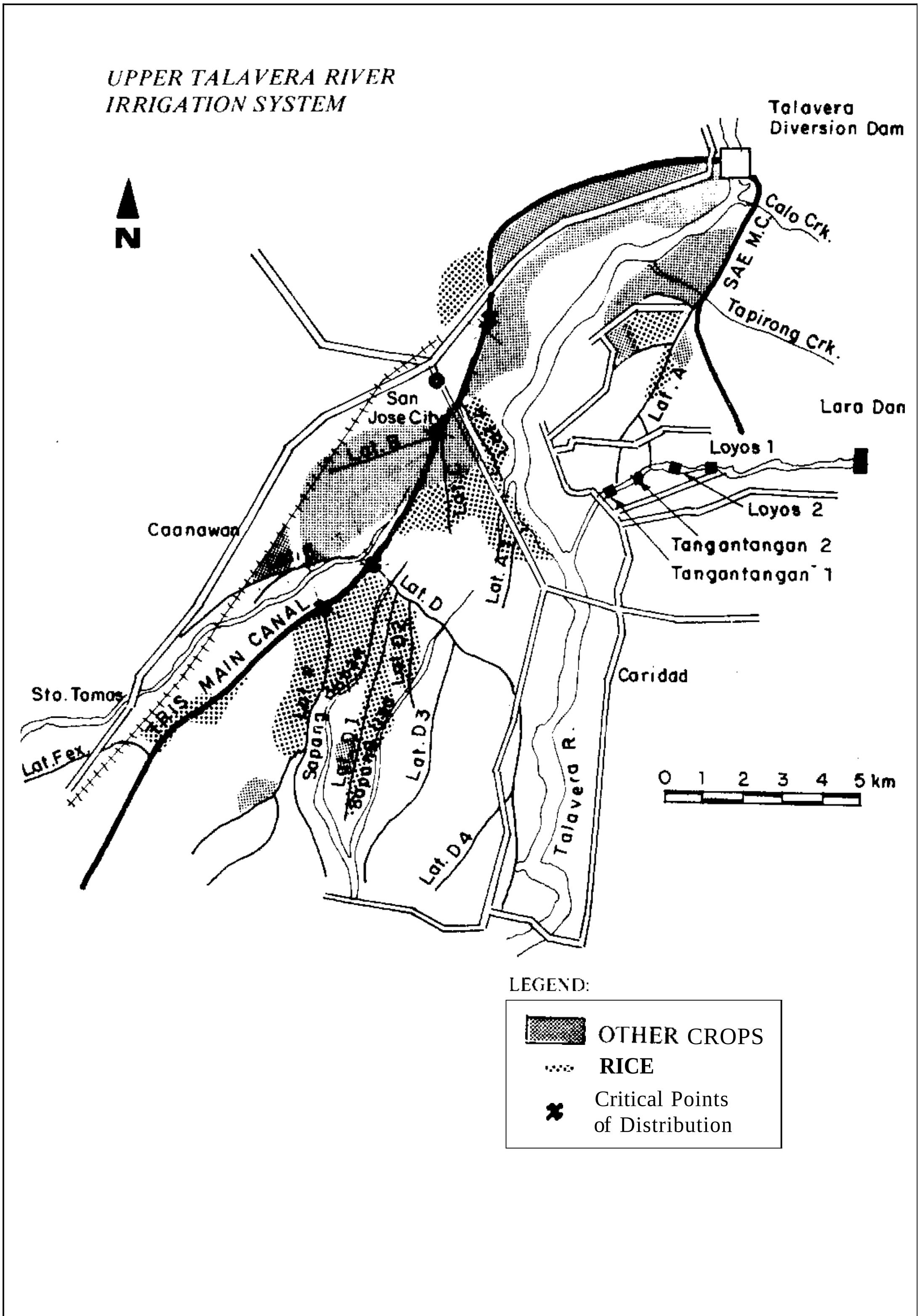

Figure 3. Map of the Upper Talavera River Irrigation System (UTRIS) in Nueva Ecija showing cropped areas for 1987/88 dry season **and** critical points of water distribution.

Table 2. Irrigated area. ha (IA), mean weekly actual irrigation diversion. mm/wk (AID), mean weekly relative water supply (RWS), and mean weekly water use efficiency, % (WUE), LVRIS, crop year 1987/88.

	Wet Season				Dry Season			
	IA	AID	RWS	WUE	IA	AID	RWS	WUE
Whole System	2220	143	2.1	60	1456	149	1.9	60
Division I	624	194	2.7	39	566	202	2.2	56
Division II	670	228	2.9	42	437	121	1.8	67
Division III	283	62	1.1	83	82	166	3.2	49
Division IV	643	87	1.5	75	437	110	1.9	59

***Table** 3.* Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), LVRIS. whole system. 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
19	May 07-13	0					
20	May 14-20	8					
21	May 21-27	53					
22	May 28-Jun 03	82					
23	Jun 04-10	213					
24	Jun 11-17	230					
25	Jun 18-24	556	121	31	377	3.4	30
26	Jun 25-Jul 01	908	120	28	279	2.5	39
27	Jul 02-08	1300	117	78	227	2.6	38
28	Jul 09-15	1924	113	22	133	1.4	100
29	Jul 16-22	2153	104	48	131	1.7	58
30	Jul 23-29	2179	99	87	137	2.3	44
31	Jul 30-Aug 05	2194	95	0	124	1.3	100
32	Aug 06-12	2204	93	16	117	1.4	70
33	Aug 13-19	2204	92	71	127	2.2	46
34	Aug 20-26	2222	91	24	123	1.6	62
35	Aug 27-Sep 02	2222	91	127	110	2.6	38
36	Sep 03-09	2222	91	348	95	4.9	21
37	Sep 10-16	2220	91	3	77	0.9	100
38	Sep 17-23	2220	91	6	121	1.4	72
39	Sep 24-30	2220	91	0	112	1.2	81
40	Oct 01-07	2220	91	4	128	1.5	69
41	Oct 08-14	2217	91	0	120	1.3	75
42	Oct 15-21	2139	91	0	144	1.6	63
43	Oct 22-28	1793	90	309	38	3.9	26
44	Oct 29-Nov 04	1484					
	Total	2220	1863	1204	2720		

WUE = (IDR/RF+AID)) × 100%

RWS = (RF+AID)/IDR

IDR values used are: Rice (land preparation) = 2.0 lps/ha
(normal irrigation) = 1.5 lps/ha

Table *4.* Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), LVRIS, whole system, 1987/88 dry season.

Week	Date	IA (ha)	IDR (mm)	KF (mm)	AID (mm)	RWS	WUE (%)
45	Nov 05-11	933					
46	Nov 12-18	703					
47	Nov 19-25	749					
48	Nov 26-Dec 02	760					
49	Dec 0349	943					
50	Dec 10-16	1168	87	12	270	3.3	31
51	Dec 17-23	1221	85	2	258	3.1	33
52	Dec 24-31	1363	85	0	231	2.7	37
1	Jan 01-07	I359	73	10	181	2.6	38
2	Jan 08-14	1393	70	0	236	3.4	30
3	Jan 15-21	1396	70	1	209	3.0	33
4	Jan 22-28	1396	70	0	72	1.0	98
5	Jan 29-Feb 04	1407	70	0	85	1.2	82
6	Feb 05-11	1438	70	0	80	1.2	87
7	Feb 12-18	1456	69	1	84	1.2	81
8	Feb 19-25	1427	68	0	116	1.7	59
9	Feb 26-Mar 04	1246	67	0	116	1.7	57
10	Mar 05-11	1167	66	0	13	1.1	90
11	Mar 12-18	1033	68	0	75	1.1	90
12	Mar 19-25	1061					
13	Mar 26-Apr 01	905					
	Total	1456	1018	26	2086		
	Mean		73	2	149	1.9	60

WUE = (IDR/RF+AID)) X 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (land preparation) = 1.5 lps/ha
(normal irrigation) = 1.0 lps/ha

October, their field will be waterlogged due to heavy rainfall. Moreover, farms will remain idle for two months if farmers will plant corn in December. Thus they opted to plant a second crop of rice. At such time, NIA did not **assure** them of sufficient irrigation water but compromised to provide irrigation until the end of December instead of the scheduled cut-off on 31 October. However, a few farmers who planted late obtained reduced crop yields due to moisture deficit.

At BARIS, WUE was 85% during the 1987/88 dry season (Table 11). Area planted to irrigated rice was 1,750 hectares, which was larger than the irrigated area during the previous dry season. A staggered water delivery schedule was implemented to accommodate this larger area. Moreover, the high WUE indicated the successful implementation of water delivery schedules. Similar values were obtained in previous dry seasons. The schedule was revised on a monthly basis to adjust to the current needs of the different sections of the system, particularly the downstream portion. The high efficiency can be attributed to the unmeasured inflows into the main canal from ARIP and also due to the effort of NIA personnel and IAs to optimize the use of available water. In addition, approximately 52 hectares were planted to irrigated corn. Technically, the corn was irrigated since they subsisted on seepage water from adjacent rice paddies and occassional rainfall. Without seepage water from adjacent paddy fields, the corn crop would have suffered moisture deficit **as** was demonstrated in 1984 when rainfall was not enough to support the crop *so* that farmers requested *flushing* or irrigation.

A third crop of corn was planted in the upstream portion of the system. This was possible due to the staggered planting schedule adopted

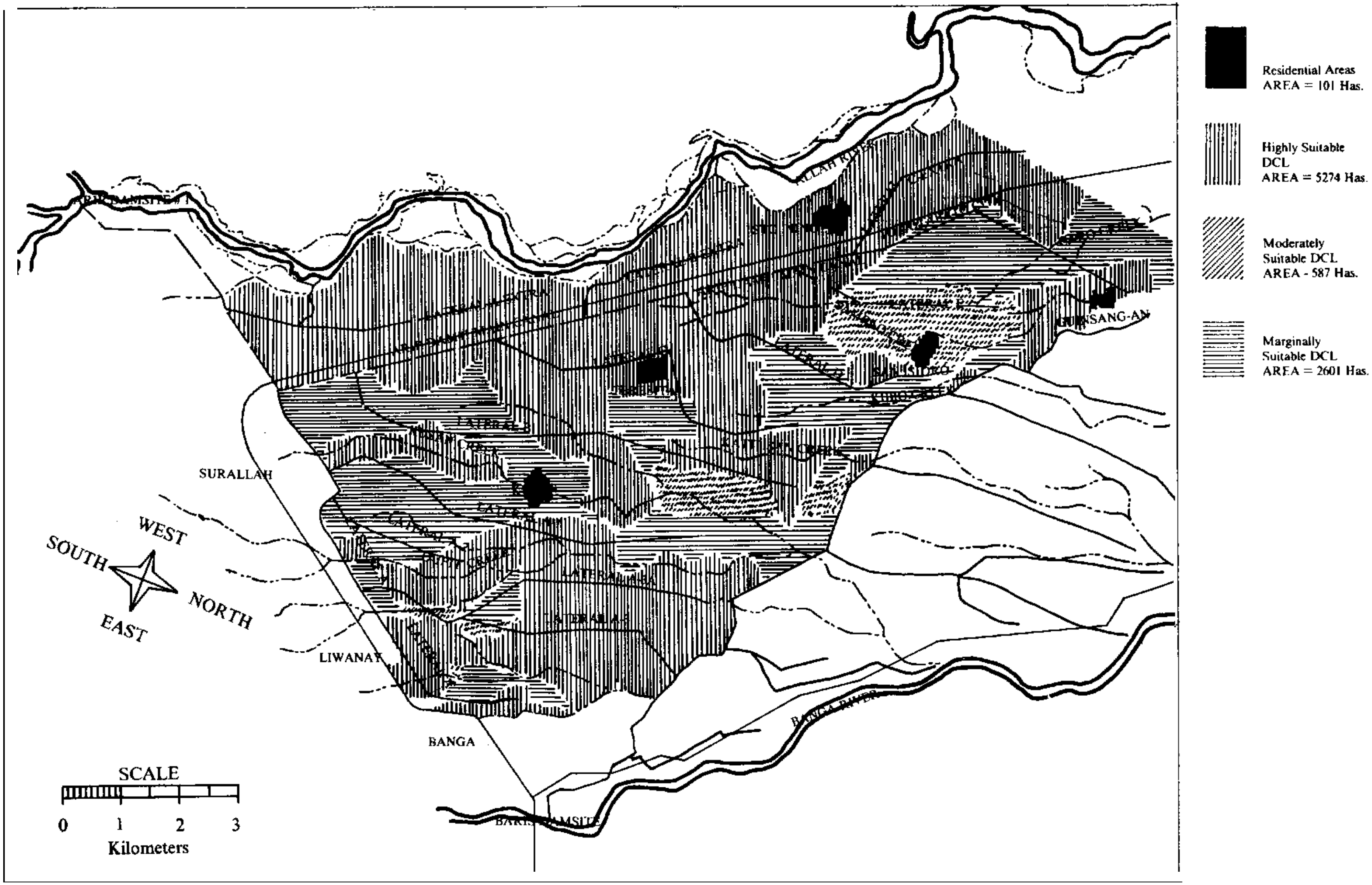

Figure 4. Suitability Map to Irrigated Diversified Crops during the Dry Season [illegible] River Irrigation Project, South Cotabato, Philippines.

Table 5. Mean water use efficiencies (WUE) and yields **by** section of systems, **1987/88** dry season.

Site	Section	Yield. kg/ha			WUE. %
LVRIS		Rice	Garlic	Mungbean	
	Whole System	n.a.	**756**	**536**	**60**
	Division I		**774**	**470**	**56**
	Division II		**855**	**300**	**67**
	Division III		**687**	**545**	**49**
	Division IV	**656**	**523**	**59**	
UTRIS		Rice	Onion		
	Whole System	**3129**	**3925**		**72**
	Upstream Area	**3225**	**4038**		**64**
	Downstream Area	**2558**	**3197**		**89**
ARIP		Rice	Hybrid corn	Native corn	
	Whole System	**3926**	**3544**	**2355**	**41**
	Upstream Area	**3734**	**3544**	**2355**	**42**
	Midstream Area	**4203**			***31***
	Downstream Area	**4101**			**57**
BARIS		Rice	Hybrid corn		
	Whole System	**3828**	**4038**		**85**
	Division A	**4192**	**4038**		**60**
	Division B	**3641**			**85**
	Division C	**3393**			**83**

n.a. -not available

which enabled upstream farmers to harvest their crop earlier than other farmers. the second rice crop **was** harvested in February. IA leaders requested NIA to arrange for credit of hybrid corn seeds from local dealers. About 160 hectares were planted to corn **as** third crop. NIA did not assure irrigation water but *flushing* was considered a possibility in case rainfall would not he sufficient. However, sufficient rain sustained the corn crop throughout its growing period.

The viability of irrigated corn during the dry season at BARIS can only he attained through the observed method whereby seepage from adjacent paddy fields and rainfall will sustain the crop. On the average, 60 hectares were planted to corn in this manner during the previous dry seasons. Farmers preferred to plant irrigated rice. It has been a practice among farmers to irrigate corn only when drought occurs, like during the **1984** dry season. Irrigation is viewed as a last resort to save a standing crop.

Lessons Learned

Irrigation practices at the farm level. The development of irrigated crop diversification at LVRIS, BP#2 and UTRIS can be attributed to two physical factors, namely, limited water supply to grow rice during the dry season and suitable soil for upland crops. LVRIS, BP#2 and UTRIS are found in Luzon where the rainfall pattern is ideal for upland crop production. In Mindanao, farmers resorted to irrigation of upland crops in times of drought.

No major land or field movement was needed to irrigate upland crops in rice-based areas. The existing paddy dikes were retained and the upland crops were planted within these paddies during the dry season. These practices are shown by studies on irrigation of garlic and mungbean at LVRIS (Pascual, **1988)** and onion at UTRIS (Agulto, **1988** and Aragon, **1988).**

Irrigation management at the system level. Other lessons learned based on prevailing practices in these sites was the role that the IAs played in water allocation and distribution during the dry season. An active or effective **IA** enhances the

Table 6. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), Bonga Pump No. 2, whole system, 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
27	Jul 02-08	0					
28	Jul 09-15	10					
29	Jul 16-22	257	I20	66	190	2.1	47
30	Jul 23-29	297	102	43	107	1.5	68
31	Jul 30-Aug 05	375	97	0	111	1.1	88
32	Aug 06-12	375	93	7	95	1.1	91
33	Aug 13-19	375	92	46	110	1.7	59
34	Aug 20-26	375	91	14	194	2.3	44
35	Aug 27-Sep 02	375	91	101	76	2.0	51
36	Sep 03-09	375	91	205	0	5.4	19
37	Sep 10-16	375	91	10	0	0.1	100
38	Sep 17-23	375	91	13	0	0.1	100
39	Sep 24-30	367	91	0	61	0.7	100
40	Oct 01-07	363	91	9	67	0.8	100
41	Oct OX-I4	315	91	0	117	1.3	78
42	Oct 15-21	262	91	0	101	1.1	90
43	Oct 22-28	153	91	205	0	3.5	29
44	Oct 29-Nov 04	51					
	Total	375	1414	719	1229		
	Mean		94	48	R2	1.7	71

WUE = (IDR/RF+AID)) × 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (land preparation) = 2.0 lps/ha
(normal irrigation) = 1.5 lps/ha

optimum use of limited irrigation water as shown at BARIS. The initiative of the IAs coupled with responsive NIA personnel and favorable rainfall pattern resulted in a high WUE and a chance to plant a third crop of corn.

At ARIP, farmers will not readily adopt irrigated crop diversification. The abundance of irrigation water and rainfall, together with unfavorable socio-economic factors (e.g., low price of corn) inhibit farmers from planting irrigated upland crop during the dry season. Studies (Caluya and Acosta, 1988; Marzan, 1988; Bayacag, 1988; Reyes and Reyes, 1988; Intal and Valera, 1988) have shown other socio-economic factors that make irrigated upland crop production a profitable alternative during the dry season.

Studies on irrigation management under LVRIS, BP#2, UTRIS, ARIP and BARIS found some irrigation practices which can serve as basis for formulating guidelines on irrigated crop diversification during the dry season. The following practices were considered effective in irrigation management for upland crops: planning with accurate records of river flow; rainfall, and irrigation facilities; parcellary mapping; meetings and farmers' participation on water allocation and distribution; and strict implementation of rotational schedule as agreed upon by the IAs and NIA. These practices were found to be effective in all sites and were made part of the proposed guidelines for irrigation management for diversified crops (Valera, et al., 1988). Another aspect in irrigation management which must be reckoned with is the priority given to rice. Because of a national policy, second priority is given to upland crops in the dry season irrigation operation. A study on the policy implications of irrigated crop diversification is also being conducted (Adriano, 1988).

Improvement Opportunities

Irrigation facilities restoration/modification. Most irrigation systems in the Philippines were

Table 7. Irrigated area (IA). irrigation diversion requirement (IDR). rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), Bonea Pump No. 2. whole system, 1987/88 dry season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
45	Nov 05-11	30					
46	Nov 12-18	30					
47	Nov 19-25	0					
48	Nov 26-Dec 02	0					
49	Dec 03-09	0					
50	Dec 10-16	0					
51	Dec 17-23	1					
52	Dec 24-31	1					
1	Jan 01-07	8	110	9	205	4.1	24
2	Jan 08-14	13	111	0	205	3.9	26
3	Jan 15-21	64	119	0	126	1.1	94
4	Jan 22-28	83	119	0	86	0.7	100
5	Jan 29-Feb 04	150	115	0	124	1.1	93
6	Feh 05-11	184	106	0	148	1.4	71
7	Feh 12-18	190	95	2	64	0.7	100
8	Feh 19-25	192	92	0	84	0.9	100
9	Feh 26-Mar 04	180	85	0	95	1.1	90
10	Mar 05-11	213	76	0	90	1.2	84
11	Mar 12-18	213	76	0	151	2.0	50
12	Mar 19-25	213	76	2	86	1.2	86
13	Mar 26-Apr 01	213	76	0	87	1.2	87
14	Apr 02-08	213	76	0	130	1.7	58
15	Apr 09-15	203	78	0	65	0.8	100
16	Apr 16-22	188	81	0	137	1.7	59
17	Apr 23-29	162	84	0	22	0.3	100
	Total		1575	13	1905		
	Mean	213	95	1	112	1.5	78

WUE = (IDR/RF+AID)) X 100%
RWS = (RF+AID)/IDR
IDR values used are: Rice (normal irrigation) = 1.5 lps/ha
Other crops = 1.0 lps/ha

designed to irrigate rice. Using rice irrigation facilities to irrigate upland crops entails some modifications, i.e., additional control structures and facilities. Inspite of the demanding nature of upland crops compared with rice, existing rice imgation facilities have been modified or have been used to provide imgation for upland crops. Adjustments and modifications have been made in LVRIS, BP#2 and UTRIS to make these systems capable of providing imgation water for both rice and upland crops during the dry season.

To properly irrigate upland crops, control structures and facilities will have to be provided. UTRIS and BARIS need restoration. Other systems are either new (e.g., ARIP) or recently rehabilitated (e.g., LVRIS). Absence of gates at the main canal structures (cross-regulators), headgates of laterals and turnouts at UTRIS and BARIS posed as obstacles in controlling water deliveries. In spite of these obstacles, the NIA personnel at BARIS were still able to deliver adequate amounts of water to the farms. Improvements in water delivery such as reliability of deliveries and reduction in losses will eventually increase irrigated area.

Farm level facilities will also have to be restored or modified to effectively irrigate upland crops. The density of farm dicthes and optimum size of turnout service area have evolved in some of the sites particularly at LVRIS and UTRIS. A study to determine the optimum farmditchdensity in order that appropriate farm level facilities and

Table 8. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), UTRIS, whole system, 1987 wet season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
20	May 14-20						
21	May 21-27						
22	May 28-Jun 03	5					
23	Jun 04-10	37					
24	Jun 11-17	103					
25	Jun 18-24	277					
26	Jun 25-Jul 01	537	121	19	575	4.9	20
27	Jul 02-08	739	120	64	258	2.7	37
28	Jul 09-15	1124	119	0	195	1.6	61
29	Jul 16-22	1472	116	5	111	1.0	100
30	Jul 23-29	1737	112	123	171	2.6	38
31	Jul 30-Aug 05	2122	110	20	130	1.4	74
32	Aug 06-12	2687	108	13	65	0.7	100
33	Aug 13-19	3060	107	109	137	2.3	43
34	Aug 20-26	3516	106	163	109	2.6	39
35	Aug 26-Sep 02	3601	103	98	144	2.3	43
36	Sep 03-09	3616	99	86	163	2.5	40
37	Sep 10-16	3611	96	26	146	1.8	56
38	Sep 17-23	3585	89	161	134	3.3	30
39	Sep 24-30	3531	91	40	137	2.0	51
40	Oct 01-07	3474	91	17	154	1.9	54
41	Oct 08-14	3327	91	58	142	2.2	46
42	Oct 15-21	3041	91	1	133	1.5	68
43	Oct 22-28	2810	91	12	148	1.8	57
44	Oct 29-Nov 04	2565	91	34	184	2.4	42
	Mean	3616	103	55	170	2.2	53

RWS = (AID+RF) / IDR
WUE = IDR / (AID + RF) × 100%
IDR values used are: Rice (land preparation) = 2.0 lps/ha
(normal irrigation) = 1.5 lps/ha

canal structures will be provided was conducted in these sites (Pascual et al., 1988). The study is expected to provide appropriate values that can serve as a guide in either rehabilitation or design of systems that will accommodate both rice and upland crops during the dry season. Improvement of existing irrigation methods at ARIP and BARIS is necessary if imgated upland crop production will be pursued. Furrow irrigation of corn has been found to be more effective in terms of water use and duration of irrigation compared with the traditional practice of basin flooding (IIMI, 1988).

Improvement in procedures and practices. Irrigation practices and procedures used by NIA were designed only for rice. Improvements or modifications of these procedures will provide NIA with a set of guidelines to effectively irrigate both rice and non-rice or mixed cropping in systems where irrigated diversified cropping is viable. Moreover, existing procedures which are actually being practiced but not recorded have to be incorporated. The following suggested improvements focus on existing planning, monitoring, implementation and evaluation procedures of NIA: 1) A computer aided mapping program as a tool for identifying parts of systems suitable for irrigated non-rice crop production is proposed (Cablayan and Pascual, 1988) to help improve the planning procedure in allocating water for rice and non-rice crop areas. 2) In determining water availability from the river and rainfall, a more frequent assessment of river flow and a more powerful rainfall probability method are suggested.

Table 9. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), water use efficiency (WUE), and relative water supply (RWS), UTRIS, whole system, 1987/88 dry season.

		Rice		Onion		Total				
Week no.	Inclusive Dates	IA (ha)	IDR (mm)	IA (ha)	IDR (mm)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
45	Nov 05-11	2286								
46	Nov 12-18	1888								
47	Nov 19-25	1557								
48	Nov 26-Dec 02	1305								
49	Dec 03-09	1183								
50	Dec 10-16	1176								
51	Dec 17-23	1261	91	205	61	87	5	170	2.0	50
52	Dec 24-31	1394	91	251	61	87	13	129	1.6	61
1	Jan 01-07	1453	91	276	61	86	4	135	1.6	62
2	Jan 08-14	1418	91	348	61	85	0	104	1.2	82
3	Jan 15-21	1395	91	378	61	85	1	96	1.2	87
4	Jan 22-28	1378	91	384	61	85	0	91	1.1	93
5	Jan 29-Feb 04	1373	91	384	61	85	5	74	0.9	100
6	Feb 05-11	1304	91	382	61	84	0	75	0.9	100
7	Feb 12-18	1161	91	372	61	84	1	92	1.1	90
8	Feb 19-25	1003	91	330	61	84	13	104	1.4	72
9	Feb 26-Mar 04	869	91	158	61	87	0	122	1.4	71
10	Mar 05-11	809	91	142	61	87	0	146	1.7	59
11	Mar 12-18	631	91	125	61	86	0	153	1.8	56
12	Mar 19-25	537	91	111	61	86	0	157	1.8	55
13	Mar 26-Apr 01	454	91	91	0	216	2.4	42		
14	Apr 02-08	384								
15	Apr 09-15	289								
16	Apr 16-22	233								
17	Apr 23-29	143								
18	Apr 30-May 06	37								
	Mean	1395	91	384	61	86	4	124	1.5	72

RWS = (RF+AID)/IDR

WUE = IDR/(RF+AID) X 100%

IDR values used are: Rice (land preparation) = 1.5 lps/ha

(normal irrigation) = 1.0 lps/ha

If a weekly assessment is to be used in predicting rainfall, the incomplete gamma function analysis which is more accurate than the five-year average currently being used is recommended provided a 20-year or longer rainfall record is available. 3) Regular annual inventory of irrigation facilities will provide an accurate assessment of the capability of the system in providing timely and adequate water to the farms. This is an existing practice that should be continued. 4) The effort exerted by NIA field personnel in soliciting IA participation in water allocation and distribution should be continued. The enthusiasm of the farmers to organize and to participate and of the NIA personnel to carry out these suggested practices must co-exist in order to attain the suggested improvement.

Nominally, all NIA systems have organized IAs that can participate in water allocation and distribution. However, there are ineffective IAs which can be made to contribute in terms of adhering to water delivery schedules and other activities that will reduce water losses. The NIA personnel should provide the necessary support in making these IAs effective. Studies have been conducted regarding IAs or organizations in irrigation. However, considering the present lethargy of IAs, what is needed are studies and resulting plans of action that will make these IAs more responsive and effective. There are practices that can be

Table 10. Irrigated area, ha (IA), mean **weekly actual irrigation delivery**, mm/wk (AID), mean weekly relative water supply (RWS), mean weekly water use efficiency (WUE), ARIP, crop year 1987/88.

	Wet Season				Dry Season			
	IA	AID	RWS	WUE	IA	AID	RWS	WUE
Whole System	4668	2i9	2.7	40	3038	202	2.6	41
Upstream Area	1857	233	3.0	35	1109	207	2.7	42
Midstream Area	1363	296	3.8	30	1208	242	3.1	31
Downstream Area	1448	93	1.3	80	721	152	2.1	57
Lateral A	1367	262	3.2	34	670	261	3.4	31
Upstream Area	606	292	3.7	30	415	280	3.8	28
Downstream Area	761	220	2.8	38	255	228	3.0	38
Lateral A-I	359	260	3.I	37	300	234	3.0	39
Lateral **A-2**	211	302	4.2	28	115	406	5.2	24
Lateral **A-3**	492	215	2.7	39		not served		
Latera! **B**	532	244	3.I	37	532	214	2.7	42
Lateral	467	200	2.6	47	467	218	2.7	41
Latera	354	171	2.3	54		not served		
Lateral E	370	126	1.7	71	330	89	1.4	76
Lateral A-Extra	130	259	1.2	83	89	**105**	1.0	**88**
Main Canal turnouts	1257	228	3.1	36	958	169	2.3	
Upstream	569	314	4.1	27	569	**190**	2.6	**51**
Downstream	688	39	0.8	93	389	154	2.1	53

emulated with appropriate modifications to suit the specific needs of the target group of farmers or ineffective IAs.

Implications and Conclusions

There are lessons to be learned in the practices and procedures employed by farmers in irrigating crops and in their participation for water allocation and delivery. NIA personnel on the other hand, have adopted existing procedures to accommodate the needs of non-rice crops while giving piiority to the irrigation of rice. Under LVRIS, BP#2 and UTRIS, the practice of irrigating rice and non-rice crop during the dry season have evolved and developed through the years. **This** was brought about by the combination of physical and socio-economic factors which made the production of irrigated non-rice crops the prevailing practice in these systems. Among the physical factors affecting irrigated mixed crop production during the dry season were limited water supply and suitable soils for upland crop production.

The abundance or relative availability of water during the dry season prompted farmers under ARIP and BARIS not to practice irrigated non-rice or corn production. Although limited, corn crops under BARIS were irrigated during the dry season through seepage from adjacent rice paddies. Farmers irrigate corn only in times of drought. Thus, limited water supply is a necessary but not a sufficient condition for farmers to practice irrigated non-rice crop production.

Farmers under ARIP, in spite of suitability of the soil and limited water supply, still prefer

Table 11. Irrigated area (IA), irrigation diversion requirement (IDR), rainfall (RF), actual irrigation diversion (AID), relative water supply (RWS), and water use efficiency (WUE), BARIS, whole system, 1987188 dry season.

Week	Date	IA (ha)	IDR (mm)	RF (mm)	AID (mm)	RWS	WUE (%)
40	Oct 0147	1500	88	71	0	0.8	100
41	Oct 08-14	1495	88	57	0	0.6	100
42	Oct 15-21	'588	88	35	50	1.0	100
43	Oct 22-28	1620	88	69	84	1.7	58
44	Oct 29-Nov 04	1547	88	68	83	1.7	58
45	Nov 05-11	1503	88	71	83	1.7	57
46	Nov 12-18	1521	88	41	40	0.9	100
47	Nov 19-25	1531	88	19	82	1.1	87
48	Nov 26-Dec 02	1339	88	0	113	1.3	78
49	Dec 03-09	1520	88	0	93	1.1	94
50	Dec 10-16	1610	88	60	89	1.7	59
51	Dec 17-23	1750	88	36	75	1.3	79
52	Dec 24-31	1750	88	76	60	1.5	65
1	Jan 01-07	1750	88	0	49	0.6	100
2	Jan 08-14	1750	88	0	62	0.7	100
3	Jan 15-21	1750	88	12	54	0.7	100
4	Jan 22-28	1750	88	2	61	0.7	100
5	Jan 29-Feb 04	1700	88	5	58	0.7	100
6	Feb 05-11	1600	88	30	58	1.1	91
7	Feb 12-18	1500	88		65	1.0	100
8	Feb 19-25	1302	88	4	86	1.0	97
9	Feb 26-Mar 04	1135	88	0	60	0.7	100
10	Mar 05-11	950	88	7	73	0.9	100
11	Mar 12-18	875	88	9	102	1.3	79
I2	Mar 19-25	800	88	0	109	1.2	81
13	Mar 26-Apr 01	725	88	90	149	2.7	37
	Total		2288	791	1838		
	Mean	1750	88	30	71	1.1	85

RWS = (RF+AID)/IDR
WUE = IDR / (RF+AID)) X 100%
IDR values used are: Rice (land preparation)= 2.0 lps/ha
(normal irrigation)= 1.5 lps/ha

imgated rice production during the dry season. Alternative non-rice crops aside from corn were tested and found suitable. However, other support services must be provided to enhance farmers to practice irrigated non-rice crop production.

Changes in the rice priority policy have to be considered, if production of irrigated non-rice crop is to increase. Existing irrigation technologies and some suggested areas for improvements are deemed necessary to help optimize the use available water supply in most irrigation systems in the country especially during the dry season.

The proposed guidelines for irrigation management for diversified crops and the results of the component studies are expected to be useful, particularly to NIA. The Diversified Crop Irrigation Training Center is expected to make valuable use of the outputs of this study.

Table 10. Irrigated area, ha (IA), mean weekly actual irrigation delivery, mm/wk (AID), mean weekly relative water supply (RWS), mean weekly water use efficiency (WUE), ARIP, crop

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Methodology for Identifying Parts of Irrigation Systems Suitable for Crop Diversification During the Dry Season

D. Cablayan and C. Pascual [1]

Abstract

The study aimed to develop a computerized methodology to identify areas suitable for irrigated diversified crops under the service area of an irrigation system and list computer software package with the same capability. The study used techniques developed for Geographical Information Systems (GIS) which is concerned with the digital capture of spatially related data (maps).

The software listed was the Map Analysis Package (MAP). It was used to analyze data from the Laoag Vintar River Irrigation System. The result obtained using maps was very gross because MAP was designed to analyze large areas requiring less precision.

The developed methodology was named Camputer Aided Mapping Program (CAMP). It was used to analyze data from the Allah River Irrigation Project. It was found that CAMP was more accurate than MAP. CAMP's output map was also clearer because it had the ability to super-impose live maps with thematic maps for easier identification of areas while MAP's output was only thematic maps.

Introduction

Most irrigation systems in the Philippines and in Southeast Asia are run-of-the-river type. Such systems consist of dams to raise water elevation in rivers or creeks for diversion to the canal networks. These systems were mostly designed to irrigate lowland rice. During the wet season these irrigation systems have reliable water supply to serve the entire service area for lowland rice planting. During the dry season, water is limited and only a part of the system, mostly planted to lowland rice, is served. Production of upland crops, which uses less water than lowland rice, could increase the irrigated area during the dry season. This strategy has been adopted by a few systems in the Philippines.

Recently plans to include irrigation of diversified crops was considered in the construction of irrigation systems. A methodology to identify areas suitable to upland crops under the service area of an irrigation system is needed. The methodology would be useful for irrigation planners in designing the irrigation network in areas suitable for diversified crops. It will also aid irrigation managers in the development of their seasonal irrigation plans and to identify suitable areas for diversified cropping. The computer-based methodology will provide for the efficient storage, retrieval, and analysis of data.

Identifying potential areas using computers for diversified cropping is a relatively new field in irrigation systems management. Gines and Kaida (1982) have developed a methodology which is macro in scope for classifying land suitability in relation to its potential for multiple cropping system in some areas in Central Luzon.

Objectives

The study aimed to develop a methodoldgy to analyze the service area of irrigation systems so as to determine the suitability of different areas for diversified crops during the dry season. The methodology used a microcomputer software to store, analyze and output spatial data (maps). The study also compared an existing microcomputer software with the developed software for mapping.

Methodology

The study used maps on soil types, land use, topography, and other spatial and physical data

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which determine the suitability of areas for upland crops. The output were also maps showing the suitability of different areas in the irrigation system for diversified crops during the dry season. Computer softwares designed to handle spatial data (maps) are called Geographical Information Systems (GIS) which is concerned with the digital capture of spatially related data and their linkage relative to one another (Tomlin, 1980). Specifically, GIS deals with query, analysis, reporting and output of these data (Archibald, 1986). A **GIS** is a set of computer programs which provides encoding, storage, analysis and output of spatially related information (Figure 1).

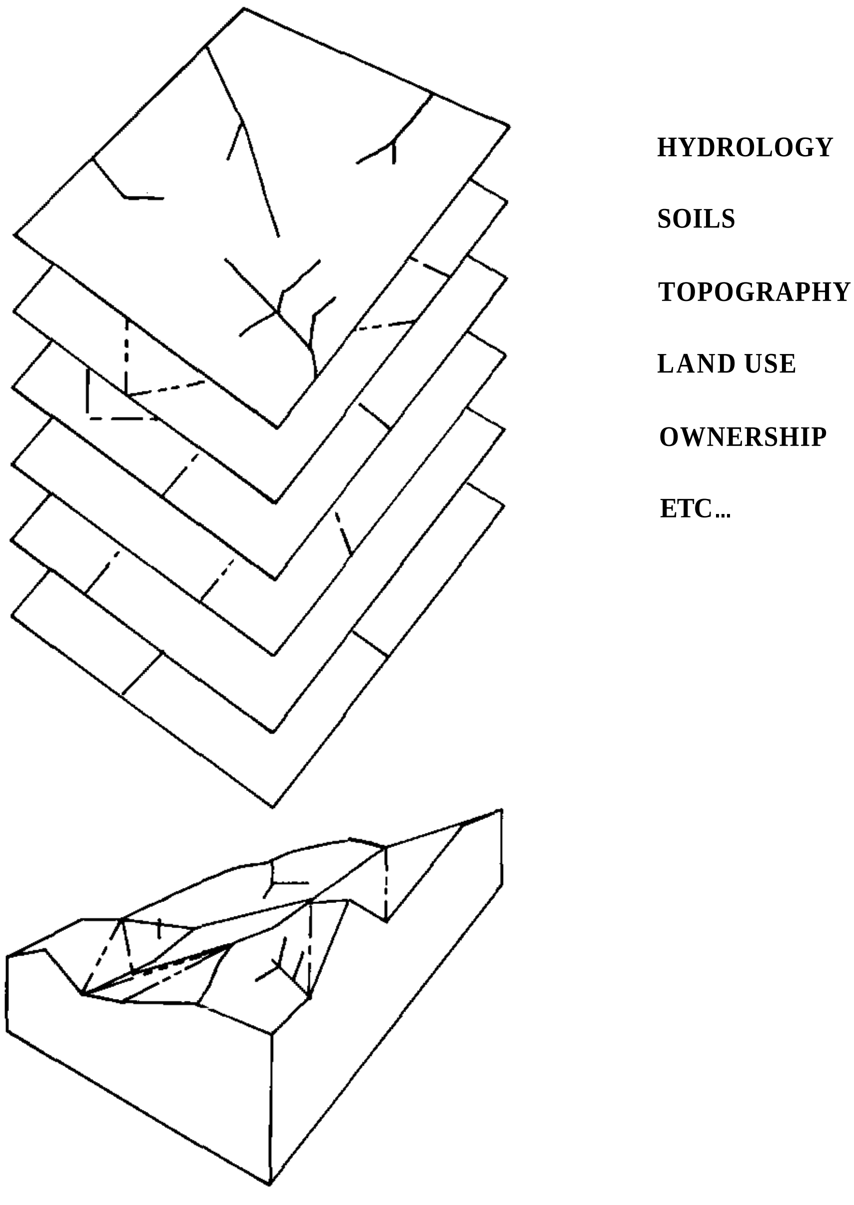


Figure ***1.*** Conceptual Framework of a GIS

There are two kinds of maps in GIS, graphic or line and thematic maps. A graphic map consists of lines representing roads, rivers, creeks, soil type boundaries, contours, ownership boundaries, etc. A thematic map is a color-coded map wherein the different areas show themes or colors representing area classifications. An example of a thematic map is a soil map wherein the areas representing different soil types appear in different colors or themes.

The input into a GIS are line maps. The first process in a GIS is to reduce these lines into digital units for the computer. This process is called *digitization*. The lines are reduced into point coordinates that determine the line (Figure 2). The first step in digitization is to assign a point in the map as the origin with 0,0 X,Y coordinates. All other points in the map should have positive coordinates. The point coordinates that determine lines in the map are the data input required by a GIS tocapture the map in a digital format. Figure3 shows an output map showing the ***digitized*** Line boundaries of soil types in the Allah River Irrigation Project.

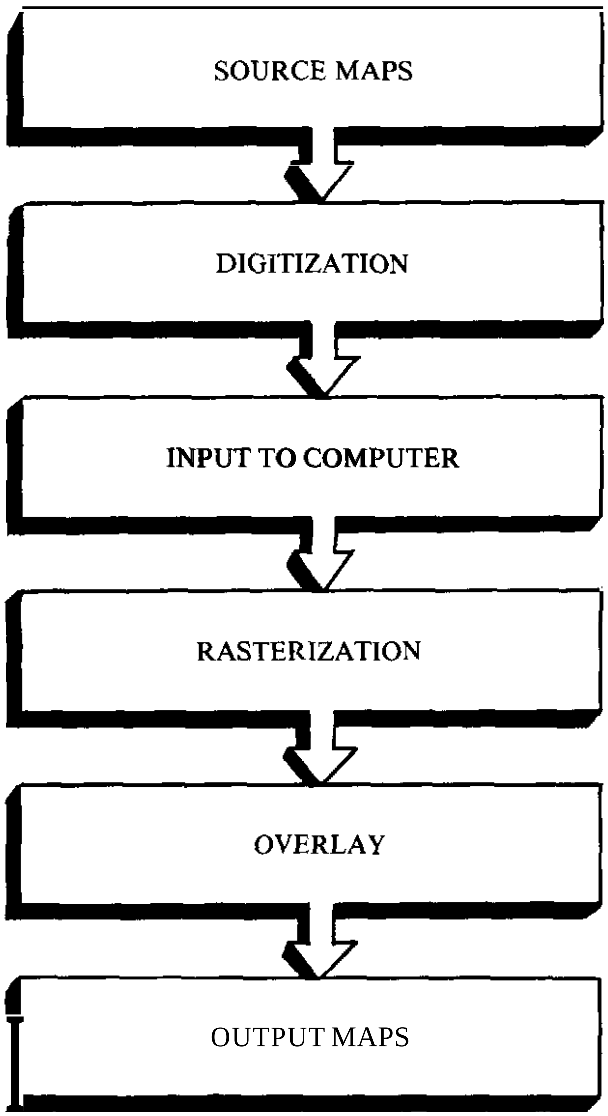


Figure 2. The GIS Flow Chart.

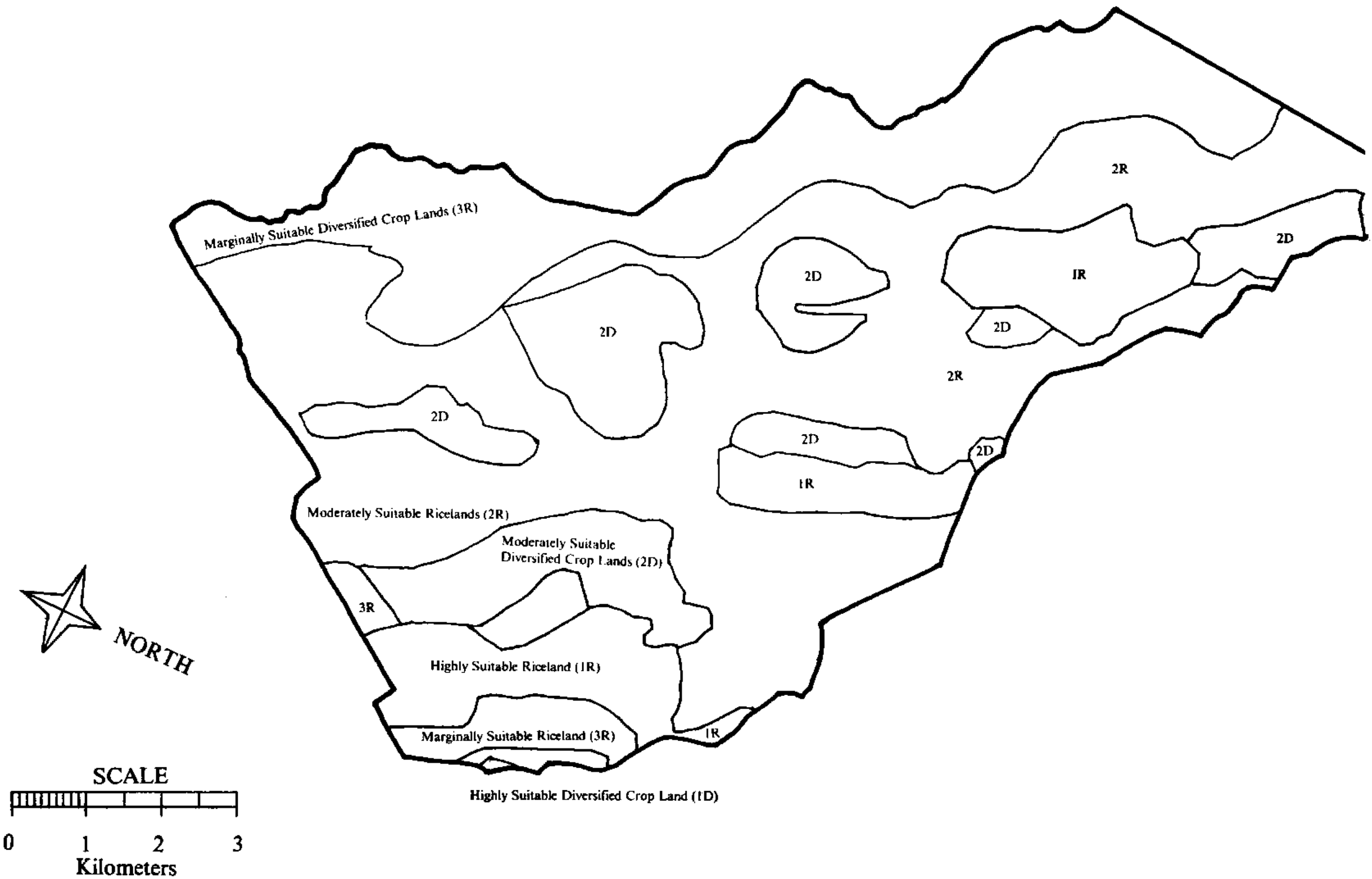


Figure 5. Digitized Line Boundaries for Land Class, Allah River Irrigation System, South Cotabato, Philippines.

The next process is called *rasterization* which is concerned with defining polygons bounded by lines in the map. The different polygons produced by this process are then assigned themes to produce thematic maps. In data output, different themes are assigned different colors or print styles. Figure 8 shows the result of rasterization of the lines shown in Figure 3.

The map analysis process is called ***overlay*** which is explained as follows: if we have a soil type thematic map with themes A, B and C, with theme A classified as best suited for diversified crops, and if we have a topographical thematic map with themes D, E and F, with theme D as best suited for diversified crops, overlay would produce the areas both with soil type theme A and topography theme D which identify areas best suited for diversified crops.

The Map Analysis Program (MAP). The GIS software tested for this study was the Map Analysis Package (MAP) which was designed for microcomputers. The microcomputer should have a fixed disk, a math coprocessor and an active memory of 640,000 bytes. Data inputed into the MAP were thematic maps. Maps stored in the computer were divided into grids. A theme (numerical data) was assigned to each grid cell based on the source map. The GIS flow chart for MAP is shown in Figure 4. Rasterization was manually done before data was keyed into the computer.

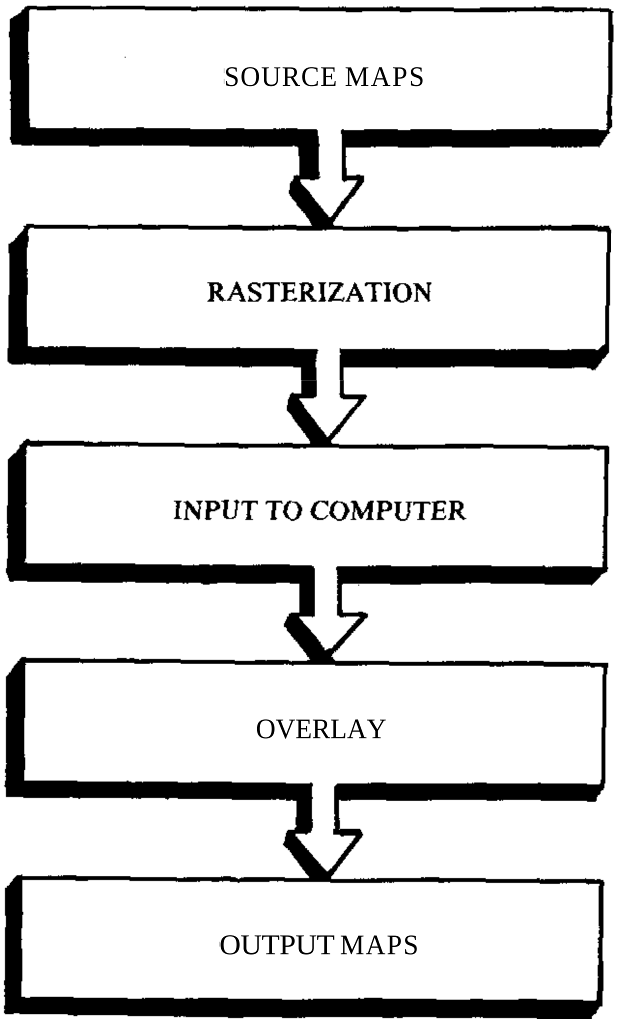


Figure 4. The GIS Flow Chart for MAP.

The processing capabilities of MAP are organized as a series of commands entered by the user. These commands resemble simple english phrases. The process involves information flow between the central processing unit of a computer, a digital storage device and input/output media. The input medium is the keyboard, the digital storage is the fixed disk, and the output medium is an ordinary line printer. The process is controlled by commands issued by the computer user. The MAP software is simple to use and assumes no prior computer programming experience of the user.

MAP was used to analyze the 2377-hectare service area of the Laoag Vintar River Irrigation System (LVRIS). Source maps used had scales of 1:100,000 and 1:50,000. These maps were enlarged to ascale of 1:40,000 which is the output map scale. Source maps were on soil type, land use, irrigability or accessibility to water source, settlements, roads, water adequacy and topography, and maps showing the location of rivers, creeks, canals, roads and residential areas. The resulting grid cell size was 125×125 meter. The area was covered by 75×60 grid cells. In each thematic map, each theme was assigned a number, which was encoded into the map cells whichcorrespond to the different themes. The different thematic maps were overlayed to produce interaction of spatial attributes.

Computer Aided Mapping Program ***(CAMP).*** CAMP was developed and written using BASIC language. CAMP is a menu driven package. **To** key-in a map into the computer, map lines are first digitized; any scaled map can serve as a source map. The source map is divided into grids of 1.0 mm width. This is easily done by redrawing the source map on an appropriate sized cross section paper. The left bottom-most point of the source map is assigned as the origin. The point coordinates of lines on the map can be determined based on this origin. The resolution (lowest measurable distance) on the output graphic maps (line maps), by the computer is 0.1 mm. On the thematic maps the resolution is **1.0** mm.

The output map has a maximum dimension of 34 cm×25 cm. This explains the difference in resolution between the graphic and thematic maps. Using the same resolution would result into 8,500,000 grid cells which entails a lengthy analysis and a large computer memory. Microcomputers used for this program were limited in speed and memory space.

The output scale can be determined based on source maps. This scale is keyed into the computer together with the scales of different source maps. The user can then input actual point coordinates based on the source map. The computer reduces these coordinates to correspond to the output scale.

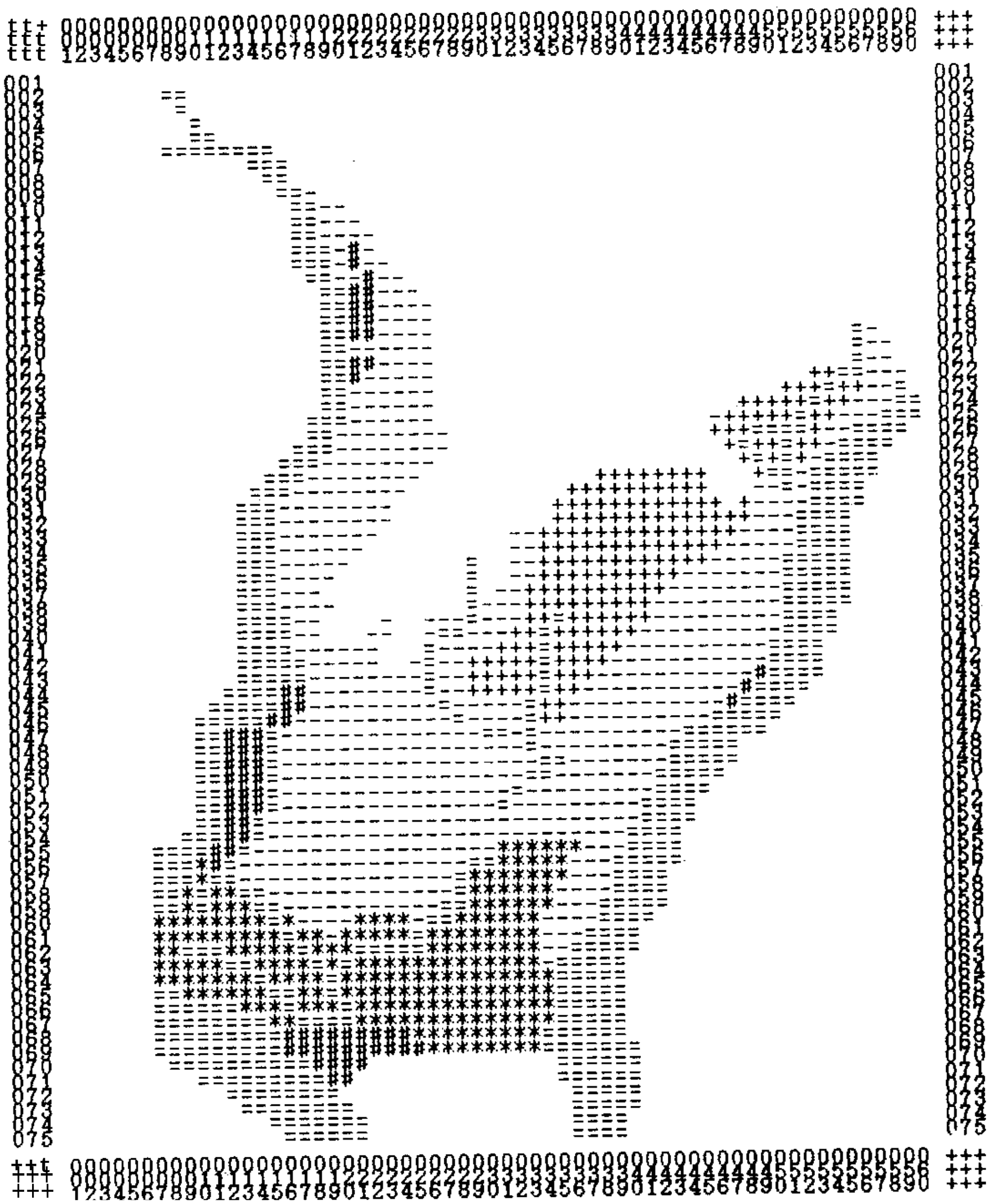
The input medium is the keyboard. The output medium is a Roland DG **DXY** 880A Plotter which is equivalent to the Hewlett Packard series 3000 Plotter. The microcomputer should be an IBM PC-AT or an equivalent.

After line maps have been keyed-in, the subprograms **for** analysis enable the user to convert the line maps into thematic maps (rasterization). The thematic maps are then overlayed to produce interactions of different map attributes.

CAMP was used to analyze the service area of the Allah River Irrigation Project (ARIP) served by Dam No. 1. The data available were maps showing the location of roads, canals, creeks, rivers; soil type map; soil series and general slope map; and pre-project land use map.

Results and Discussion

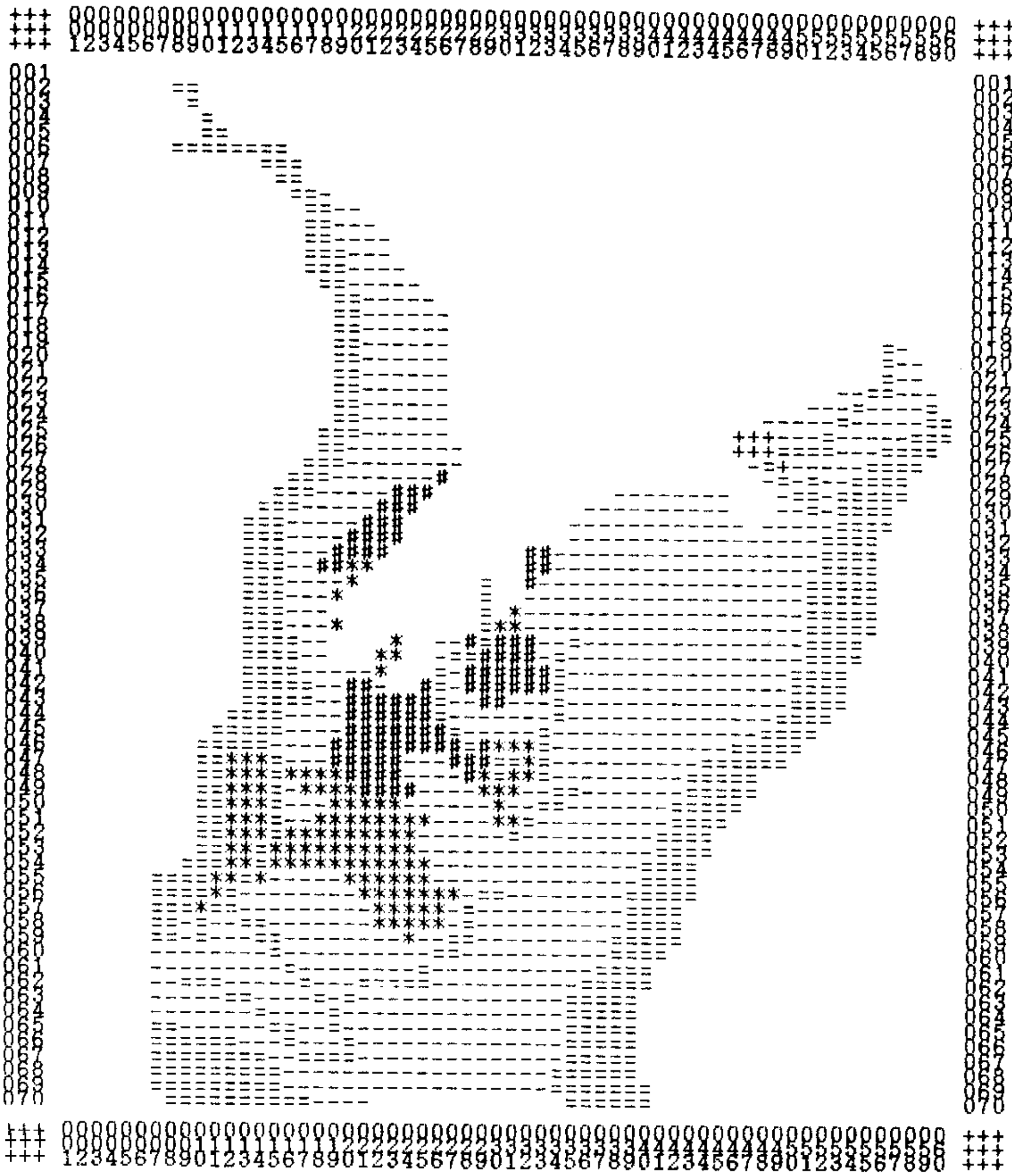
Suitability to irrigated diversified ***crops*** during ***the*** dry **season** *at* ***LVRIS*** using MAP. Soil was classified as heavy, medium and light textured. Heavy textured soil (clay to clay loam) covered 311 hectares while medium (loam to silt loam) and light textured (sandy loam) soil covered 1103 and 352 hectares, respectively (Figure ***5).*** Land **slope** was characterized as flat, gently sloping, undulating and steep. Flat lands covered 972 hectares, gently sloping 7 hectares, undulating 127 hectares and steep slopes **96** hectares (Figure 6). The land suitability map was obtained by overlaying topography with soil type (Figure **7).** Medium textured soils with slopes of 0-3% were considered as highly suitable and these covered 832 hectares. Heavy soil, relatively sloping (with slopes of 5-8%) were considered as moderately suitable and these covered 302 hectares. Light textured soil (sandy loam) with steep slopes were considered as marginally suitable and these covered 522 hectares. Built-up areas, flood areas and sand dunes were considered as unsuitable and these covered 270 hectares. This suitability map could be further enhanced with inclusion of drainage in the area.



SOILS

Symbol	Type/Description	Grid cell count	Area, ha
-----	Rivers and creeks	581	
—	Heavy textured soils	199	311
++++	Medium textured soils	706	1103
*****	Light textured soils	225	352
#####	Flood areas and sand dunes	73	114
	Unclassified		497
	TOTAL SERVICE AREA		2371

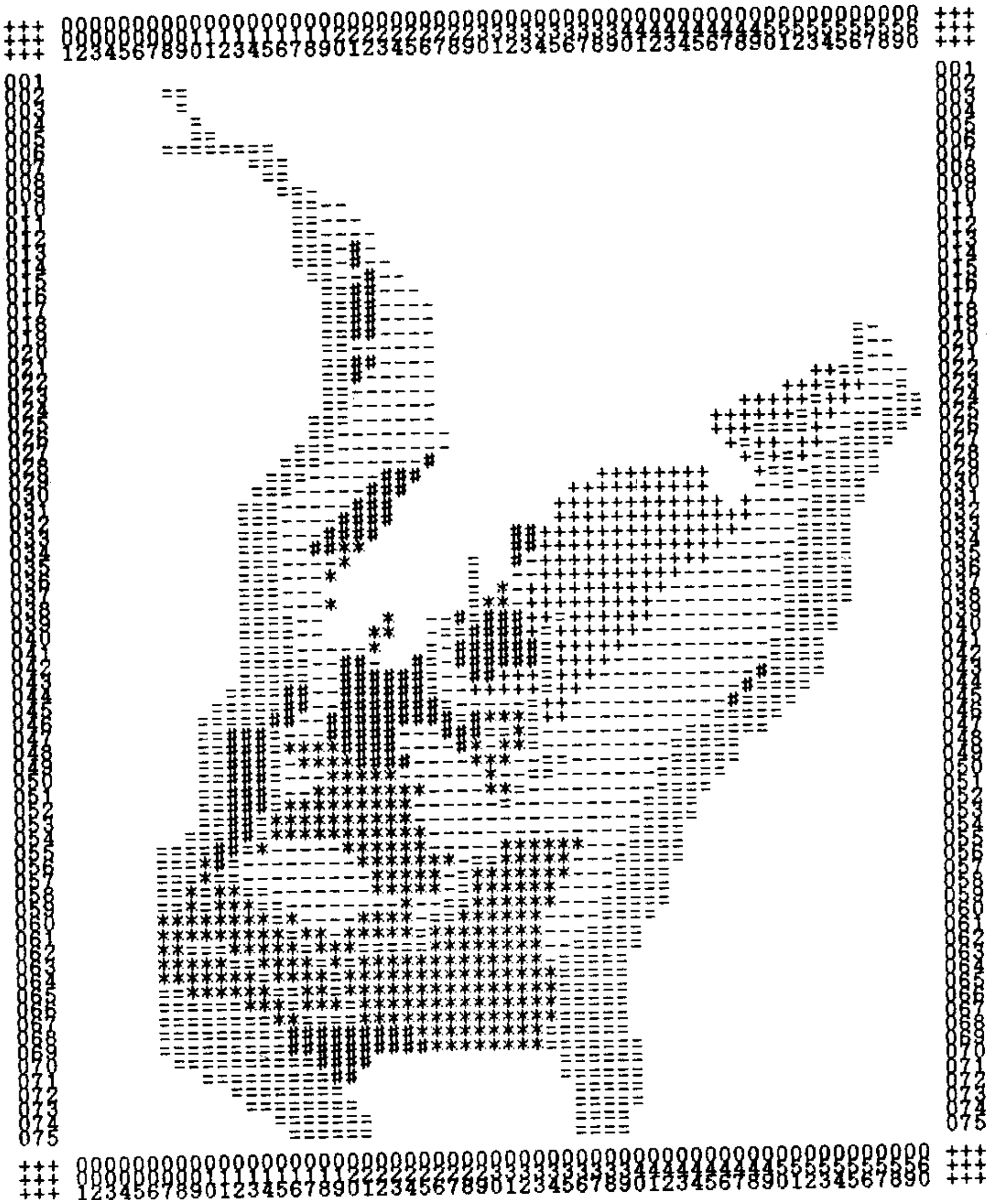
Figure 5. **Soil types, Laoag-Vintar River Irrigation System, Ilocos Norte, 1988.**



TOPOGRAPHY

Symbol	Type/ Description	Grid cell count	Area, ha
====	Rivers and creeks	582	
	Flat (0-3% slope)	972	1519
++++	Gently sloping (4% slope)	7	11
*****	Undulating (5-8% slope)	121	198
#####	Steep slopes	96	150
	Unclassified		519
	TOTAL SERVICE AREA		2311

Figure 6. General land, slope, Laoag-Vintar River Irrigation System, Ilocos Norte, 1988.



LAND SUITABILITY

Symbol	Type/Description	Grid cell count	Area. ha
_____	Rivers and creeks	581	
_____	Highly suitable	520	832
++++	Moderately suitable	189	302
******	Marginally suitable	326	522
######	Unsuitable	169	270
	Unclassified		451
	TOTAL SERVICE AREA		*2311*

Figure 7. Suitability of different areas to irrigated diversified crops during the dry season, based on topography and soil type, LVRIS, Ilocos Norte, 1988.

There was an attempt to overlay present land use with the produced suitability map. However, the land use map entered into the computer needed further verification. Water adequacy and accessibility thematic maps were also developed for overlay process to further refine the suitability map.

MAP can only handle maps with 100 by 100 grid cells. In the scale used for LVRIS, one grid cell was equivalent to **1.5** hectares. Errors in encoding were encountered when a grid cell was at the boundary of two themes: the user usually assigned the grid cell to a theme occupying a greater part of the cell. The calculated areas did not equal the computed areas if one used a planimeter. The output map was not readily understandable as it did not show line attributes and names. For the output to be useful, it should be redrawn with line attributes superimposed to actually identify the locations of different themes. Compared with other **GIS** softwares, MAP was found to have some limitations. MAP may be used for regional planning hut not for location-specific planning activities which require greater precision. However, anybody can use it even with minimal knowledge on microcomputers.

Using *CAMP to the ARIP Service Area*

Soil type. In ARIP Dam No. 1 area, there arc six soil types; three are diversified croplands (DCL) and three are ricelands (RL) (Table I). DCL and RL were further classified as highly, moderately, and marginally suitable. Marginally suitable DCLs were found near the hanks–of the Allah River (Figure 9). They had very light textured soil (sandy loams) with slopes of 0-2%. With adequate irrigation, these can be highly suitable DCLs during the dry season and moderately suitable RLs during the wet season. Moderately suitable DCLs had sandy clay loam soil with slopes of 0-1%. With sufficient irrigation they can become highly suitable DCLs during the dry season and highly suitable RLs during the wet season. Highly suitable DCLs had clay loam soil with slopes of 0-1% and will have the same classification under irrigated condition.

Marginally suitable RLs had clay to clay loam soil and were either low lying flat lands located near drainage waterways or with very steep slopes which need to be levelled before they can he planted to lowland rice. Moderately suitable RLs had clay loam to sandy clay loam soil and were relatively flat lands with poor to good drainage and high water tables during the wet season. Highly suitable RLs had clay to clay loam soil with good drainage.

Table 1. Soil Types, ARIP dam #1 area, 1988.

Soil Type	Area (ha)
Ricelands (RL)	5,300
Highly suitable RL	1,080
Moderately suitable **RL**	**3,980**
Marginally suitable RL	**240**
Diversified croplands (DCL)	3,260
Highly suitable **DCL**	40
Moderately suitable DCL	**1,470**
Marginally suitable **DCL**	**1,750**
Total Service Area	8,560*

* Includes areas occupied by roads, irrigation canals and creeks.

Pre-project ***land use.*** The **ARIP** Dam No. 1 area had four general land use classes before the project. Residential areas comprised 100 hectares, coconut areas 140 hectares, corn areas **3,950** hectares and rice areas **4,370** hectares (Table **2** and Figure 10). Regardless of **soil** type, areas planted to corn and coconut were characterized **as** having good drainage while areas planted to rice had good to poor drainage.

Table 2. Pre-project land use, ARIP dam #1 area.

Land **Use**	Area (ha)
Residential areas	**100**
Coconut areas	**140**
Corn areas	3,950
Lowland rice areas	**4,370**
Total Service Area	**8,560***

* Includes areas occupied by roads, irrigation canals and creeks.

Suitability ***to*** irrigated *diversified* ***crops*** during the ***dry*** season. Corn and coconut areas regardless of **soil** type were classified **as** highly suitable for irrigated crop diversification during the dry season. Highly suitable ricelands had good drainage and were classified **as** moderately suitable. Marginally and moderately suitable ricelands had good to poor drainage and were classified **as** marginally suitable. Areas classified **as** diversified crop lands regardless of pre-project land **use** were also classi-

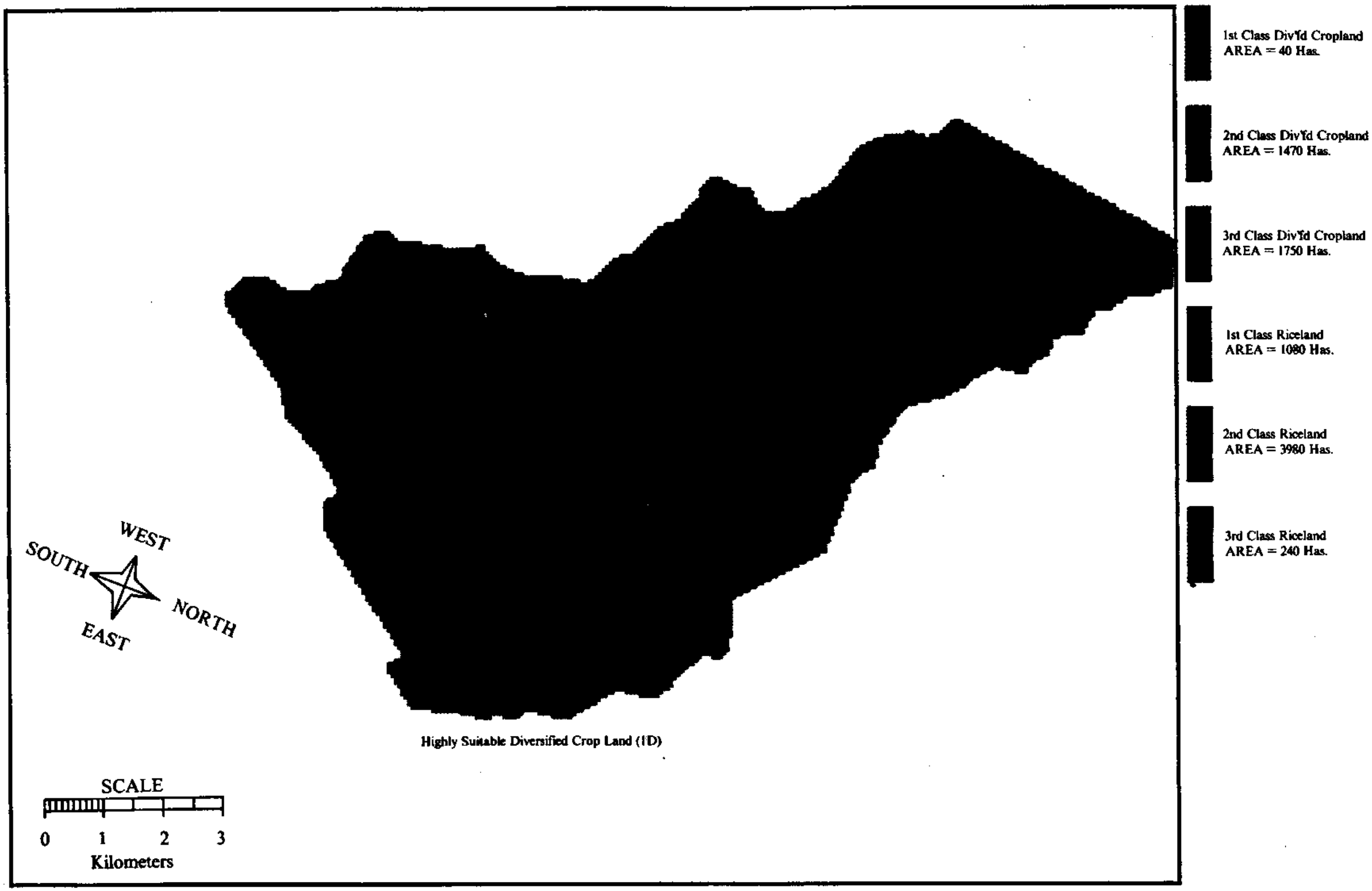


Figure 8. Thematic Map for Land Class Produced by Rasterization, Allah River System, South Cotabato.

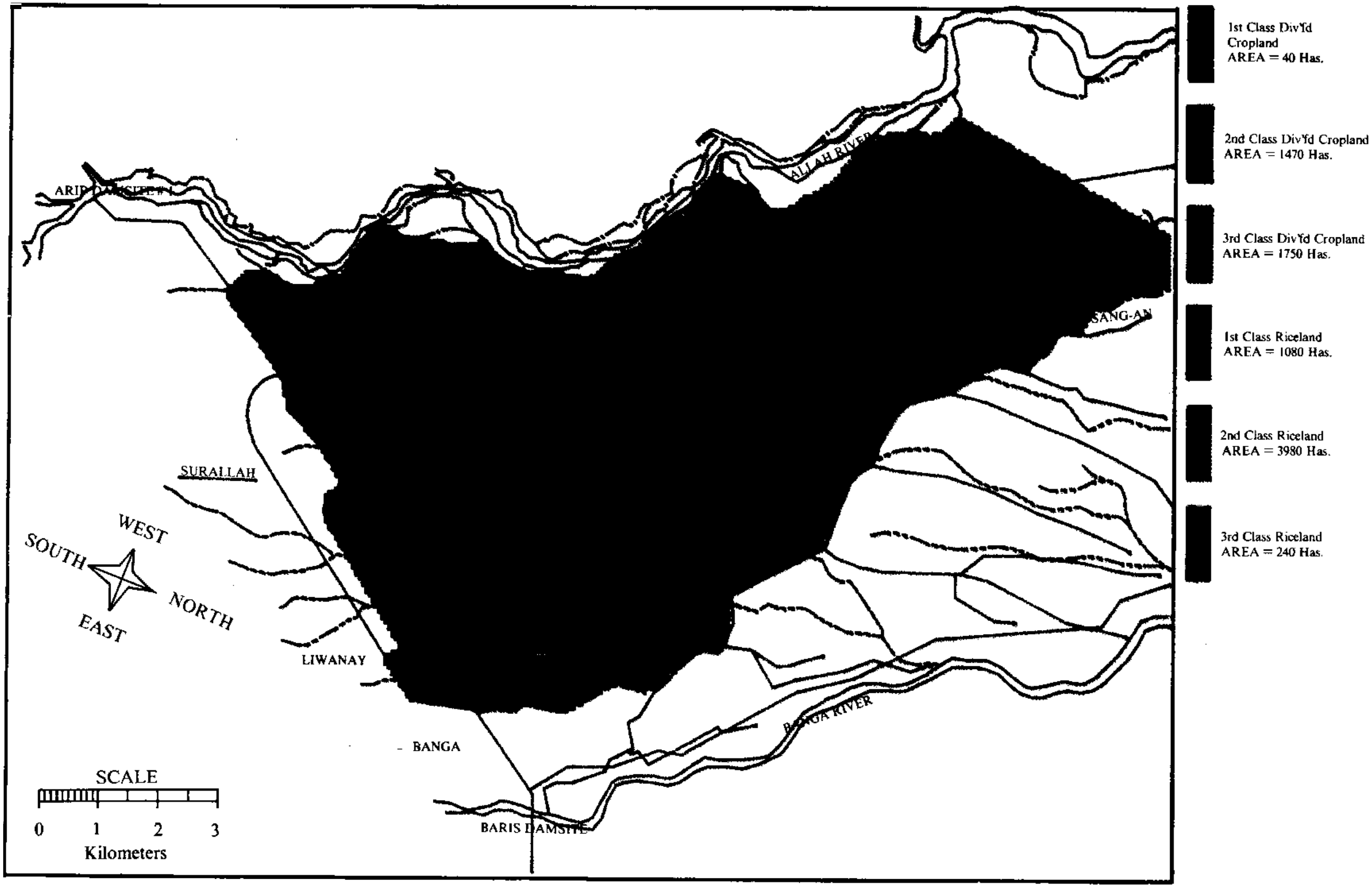


*Figure 9.*Soil Class Map, Allah River Irrigation Project, South Cotabato.

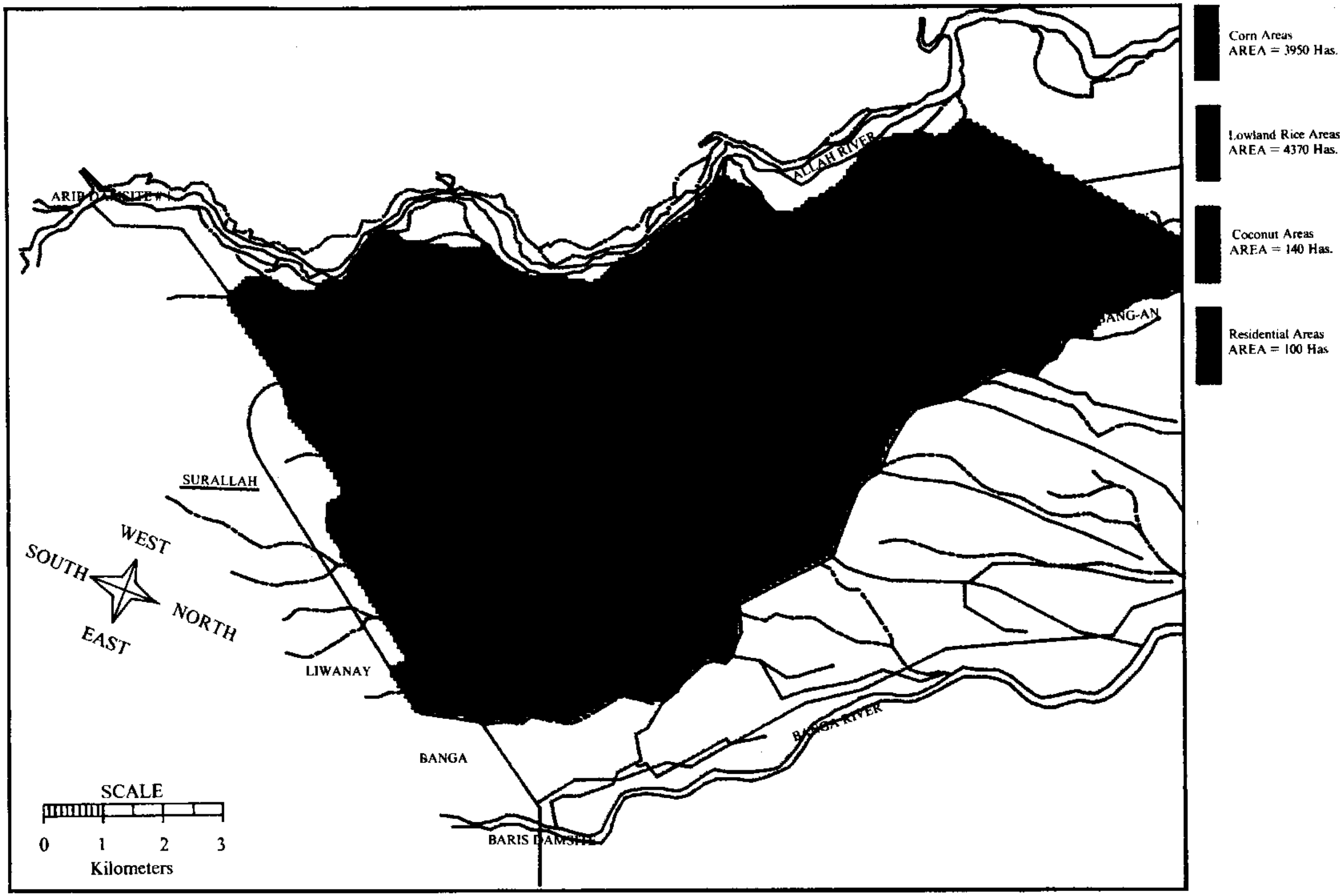


Figure 10. Pre-Project Land Use Map, Allah Irrigation Project, South Cotabato.

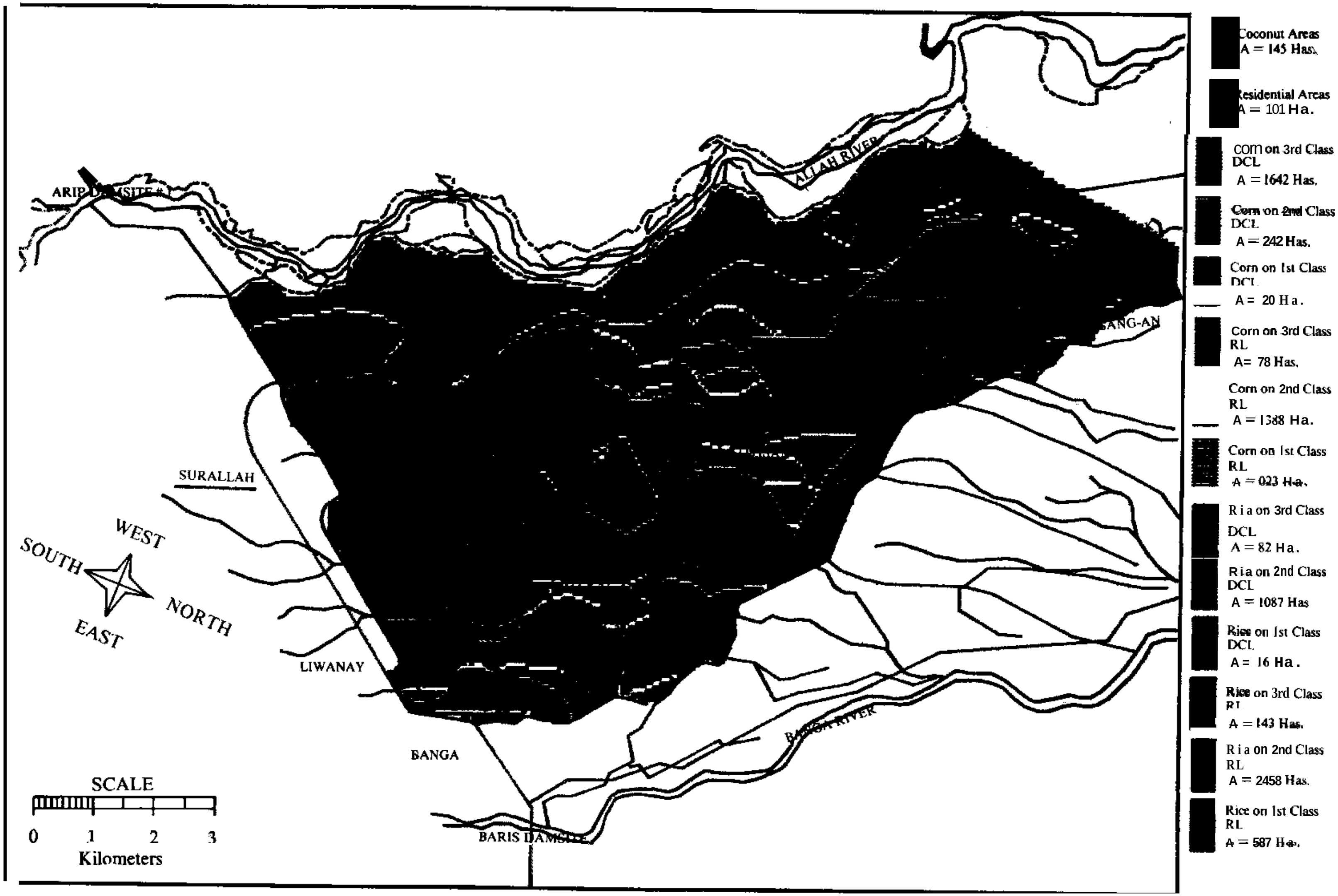


Figure 11. **Soil Class and Pre-project Land Use Overlay, Allah River Irrigation Project, South Cotabato.**

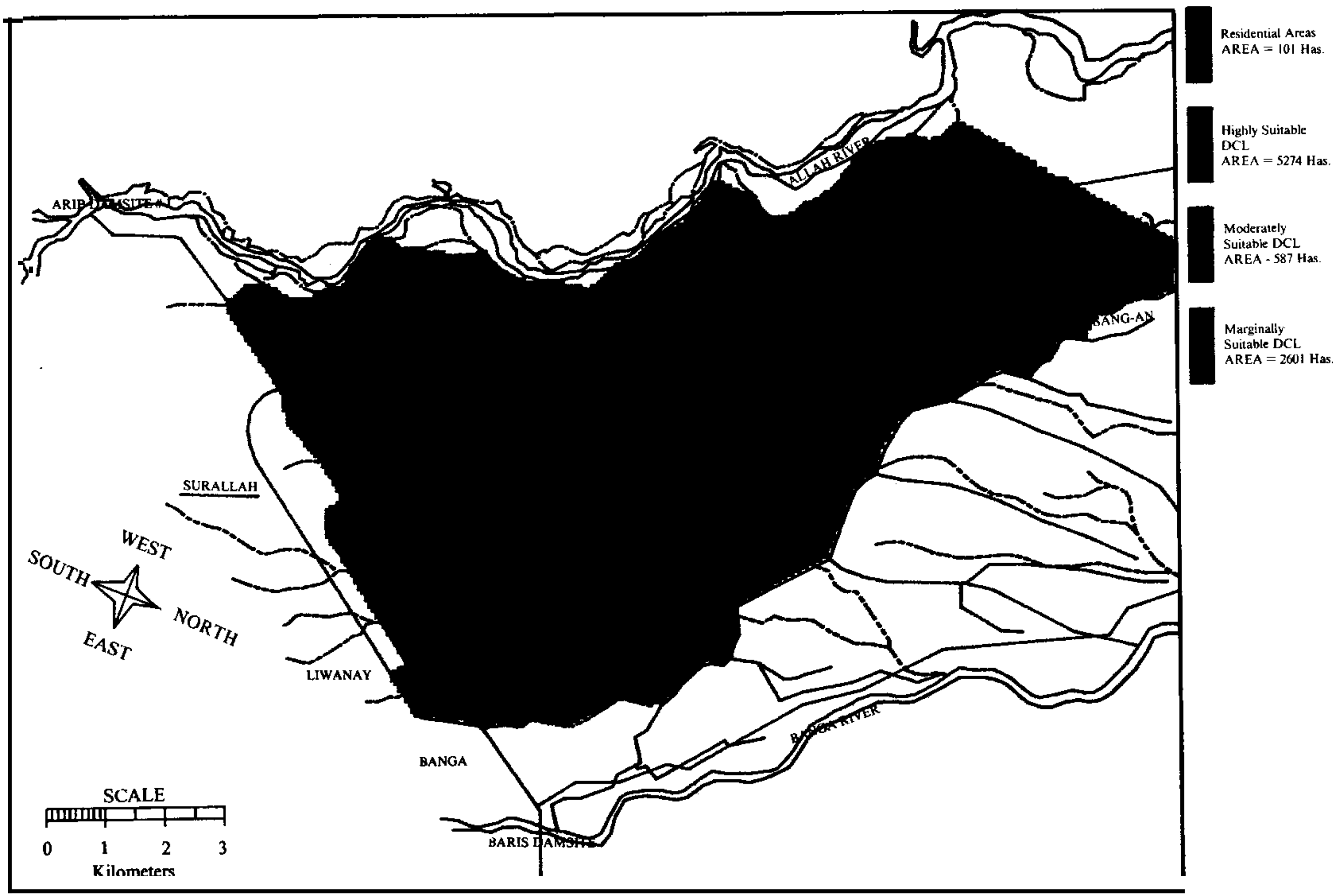


*Figure 12.*Suitability Map to Irrigated Diversified Crops During the Dry Season, Allah River Irrigation Project, South Cotabato.

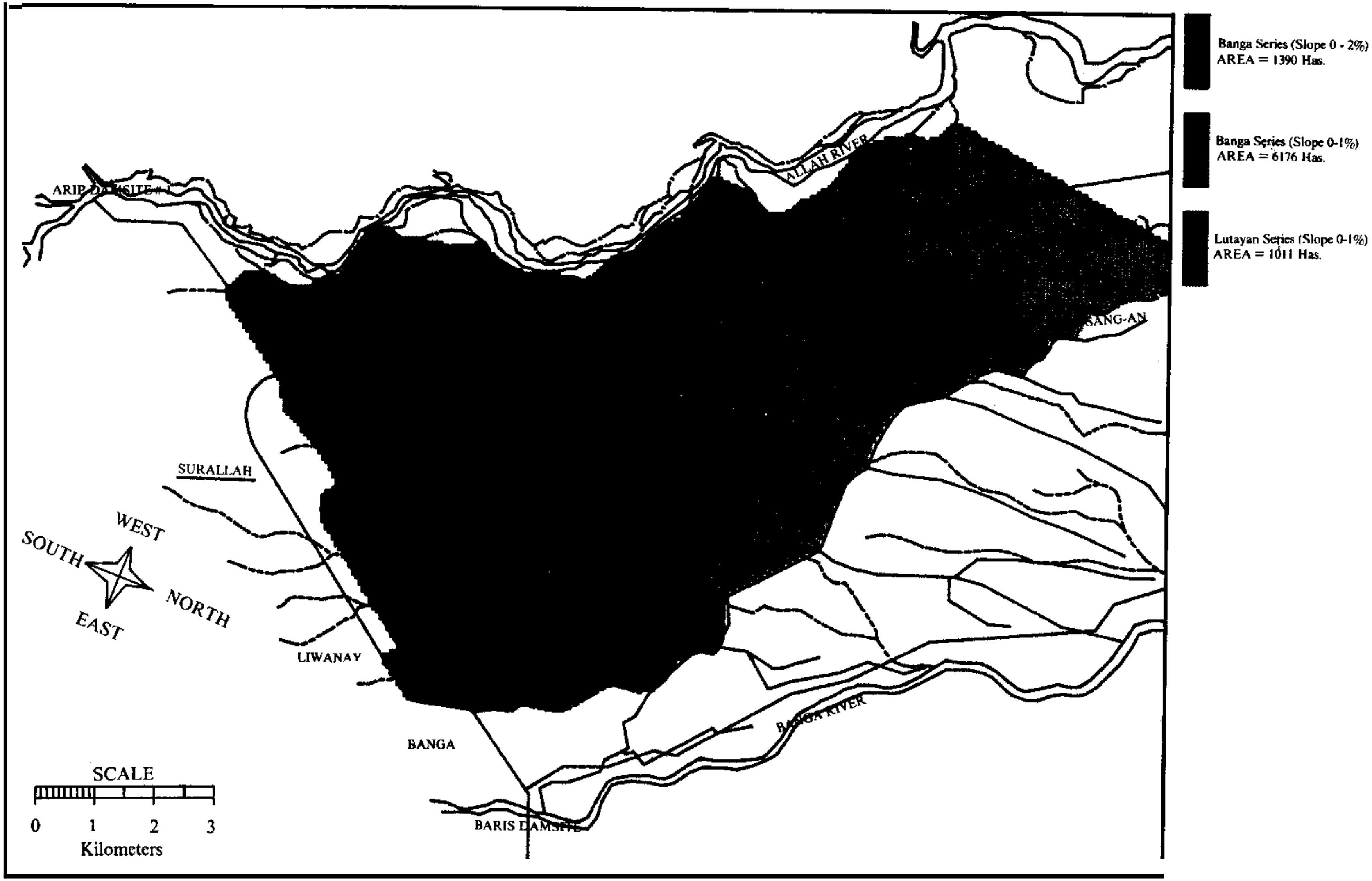


*Figure 13.*Soil Series and General Landslope Map, Allay River Irrigation Project, South Cotabato.

fied as highly suitable. The output map showing this suitability classification was obtained by overlaying the soil type thematic map to the pre-project land use thematic map (Figures 11 and **12).** Classified areas which were highly suitable for irrigated crop diversification during the dry season covered **5,270** hectares. Areas with moderate and marginal suitabilities covered **590** and **2,600** hectares, respectively. Of the total service area of 8,560 hectares, 100 hectares were residential areas. However, the total service area includes roads, irrigation canals and creeks, thus the difference from the estimated service area of 7,300 hectares. For a more accurate classification, drainage characteristics should be well defined and used in the overlay process.

Soil** series **and general land slope. The map available for this purpose was very gross in terms of land slope classification (Figure **13).** This was not used in overlay process as most of the areas classified with 0-2% slope were mostly classified as corn areas before the project.

CAMP was more accurate than MAP. For ARIP which was three times larger than LVRIS. CAMP had grid cell sizes of one-third hectare. With this accuracy, errors at boundaries of different themes were minimized. However, CAMP was not capable to display contour lines and conduct three dimensional analysis. It was not designed to produce raster maps using laser or ink-jet printers, which is a faster way to produce raster maps. Output of raster maps with CAMP is slow not because of computer speed but rather of plotter speed. CAMP also provides for viewing of maps on the computer visual display unit (VDU). Like MAP, anybody even with minimal knowledge on computers can use CAMP.

Conclusions and Recommendations

MAP, a GIS software was very gross and was not adoptable for accurate analysis of irrigation system. It was capable of identifying the position of areas suitable to diversified crops in a system but not to accurately represent the area. The developed software CAMP was more accurate. The output maps accurately identified the areas with different suitability to upland crops. CAMP can produce thematic maps overlayed with line features, like roads, canals and creeks for easier identification of canal networks serving the different areas. The CAMP output can be readily used by irrigation managers for planning.

To improve CAMP, a digitizer could be included with the hardware set-up. A program to use the digitizer as the input medium should then be developed. A digitizer is a computer peripheral consisting of a board and a digitizer pen or similar gadget. A map is attached to the digitizer board. A coordinate in the map is established for reference and entered into the computer. Lines are then traced using the digitizer pen. The digitizer pen relays the pen's position to the computer as the point coordinates of the line being defined. The digitizer simplifies the input process of maps to the computer. An ink-jet printer will facilitate printing of raster maps. Additional programs for contour line drawing and three-dimensional analysis should also be added to the CAMP software. Three-dimensional analysis is useful in identifying location of canals and other irrigation structures and computation of earthwork volumes for cost estimation.

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Overview of Crop Diversification in the Upper Talavera River Irrigation System

Honorato L Angeles [1]

A crop diversification project was implemented by the Central Luzon State University (CLSU) with funding from the International Irrigation Management Institute (IIMI). It aimed to determine the reasons why farmers diversify their crops during the dry season and the factors which farmers consider in determining farm size planted to non-rice crops.

Three studies were conducted in the area sewed by the Upper Talavera River Irrigation System (UTRIS) in San Jose City. The studies were:

1) On-farm water management practices for upland crops;
2) On-farm land preparation practices for irrigated diversified crops; and
3) Comparative profitability analysis of rice and onions planted during the dry season under irrigated conditions.

Study 1 documented on-farm water management practices for diversified crops during the dry season: Study 2 dealt on land preparation practices for irrigated rice during the wet season and diversified crops during the dry season; and Study 3 concentrated on the profitability analysis of onions and rice and generated information on marketing, credit and problems encountered by farmers in their operations.

Study 1 revealed two methods of land preparation employed by farmers - the *dayos* or raised-bed method and the *latag* or mulched-bed method. The *dayos* method requires three to four plowing and three to four harrowing operations. The *latag* method requires no tillage at all, or at most, only one plowing and one rotavating operation. Farmers received water from the main and supplementary farm ditches of UTRIS. No other water source was tapped. Border irrigation was practiced by the farmers in irrigating upland crops. The number of irrigation applications ranged from seven to eight for the *dayos* method and from four to five for the *latag* method. Irrigation time ranged from 25-68 min using the *dayos* method and from 19-63 min using the *latag* method, depending on the size of area irrigated.

Irrigation water was applied every three to four weeks for the *latag* method and one to two weeks for the *dayos* method. Stream size (inflow) ranged from 10-35 liters per second (Ips) for the *dayos* method and from 8-50 Ips for the *latag* method depending on the size of the area irrigated. Farmers used the main farm ditch, supplementary farm ditch, intercepting or seepage ditch, and the farm intake and offtake structures. The total length of the main farm ditch from the turnout to the farm intake ranged from 101-452 meters depending on the location of the farms. Each plot or onion field was provided with a drainage ditch and one to three intake and/or offtake structures. There were two to four checks constructed from the main farm ditch to the field for every irrigation. Hill and row spacings of onions ranged from 10-15 cm.

Fertilizer was applied by broadcasting in either basal or split amounts at a rate of 117 to 415 kg/ha and using 16-20-0, 21-0-0-(24), Urea, 14-14-14, and 12-12-12. Manual weeding was done 30-35 days after transplanting. In addition, weedicides were applied 3-10 days after transplanting. Under the *latag* method onions were harvested 86-92 days after transplanting with yields ranging from 15-17 t/ha using the Yellow Granex variety and 5-14 t/ha using the *tanduyong* variety. Under the *dayos* method, yields ranged from 26 to 37 t/ha using the Yellow Granex variety.

Study 2 found that farmers practiced primary tillage by dryland plowing using draft animals for rice production during the wet season. Plowing commenced in either June or July as soon as water supplied through irrigation or rainfall was enough to wet the upper 15 cm plow layer. Harrowing and puddling were done in late July when there was enough diversion flows and sufficient rainfall to

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allow impounding of water in paddies. It usually took eight weeks for farmers to prepare their lands for planting. In all farms, land preparation involved one plowing and two harrowing operations.

The farmers had varied land preparation practices in converting soil from puddled condition during the wet season into well-aerated condition for onion production during the dry season. Variations in land preparation were due to variations in the method of planting and tillage levels. Taking the date of rice harvest as the focal date, land preparation for onion production was completed within eight weeks. Labor and power requirements for land preparation ranged from 140-245 hr/ha which included primary and secondary tillage operations, flooding the field twice, construction of temporary levees, drainage canals and imgation ditches, and mulching for the *latag* method.

The factors considered by farmers in converting land from puddled lowland to upland condition were: familiarity with the rice-non-rice cropping pattern, the relatively smaller farm size for onion production, availability of labor and power, medium-textured soil which promotes better root growth, and practices which effectively control weed growth.

Results of Study 3 showed that onion production was more profitable per unit area than rice. However, income realized from onion farming varied widely among farms than rice due to price fluctuation. Expected profit was the primary consideration when selecting what upland crop to plant. Availability of water was not a limiting factor during the dry season except when drought is experienced during the wet season. Market size influences the size of area to be planted to rice and onion.

Non-institutional sources of credit were preferred by onion growers while rice farmers used their own savings to finance their farm operations, Both onion and rice farmers had the same marketing practices. Farmers sold their produce to local buyers and were paid in cash. However, onions were either picked-up at the farm or at the farmers' houses while rice were delivered to the buying centers.

Farmers encountered more economic than technical problems. Production constraints were the lack of capital and high cost of inputs. Water scarcity was more of a problem to rice fanners than to onion growers. There were lesser post-harvest-related problems due to outright selling and immediate payment of credit after harvest. Marketing problems were low prices and inadequate market outlets.

Therefore, economic factors affected crop diversification. Farmers would be encouraged to plant non-rice crops if there would be a market for their produce and higher prices offered comparative with that of rice.

On-farm Water Management Practices For Upland Crops

Ireneo C. Agulto[1]

Introduction

The Upper Talavera River Irrigation System (UTRIS) has an approximate service area of 4,000 hectares. Of the total service area, only 38% is irrigated during the dry season. Questions on why the irrigated area during the dry season is much lower than the service area have been raised. Is the available water supply sufficient only for 38% of the total command area of UTRIS? Do farmers use too much water in irrigating their crops? To answer these questions, there is a need to determine how much water a farmer actually delivers to his field during irrigation. If the amount of water applied and water requirement of the planted crop are determined, availability of excess water throughout the growing season and consequently, increase in irrigated area can also be determined.

A study was then conducted to answer the above questions. The study aimed to: (1) Document and analyze current on-farm water management practices in diversified cropping during the dry season and (2) Develop on-farm water management practices for at least one upland crop.

Methodology

On-farm water management practices employed by farmers were observed. Field observations and actual interviews were conducted to determine the following:

1. Crops that are usually planted during the dry season
   a) Planting distance between hills and rows
   b) Yield
2. Size of area planted
3. Sources of irrigation water
   a) Seepage from adjacent ricefields
   b) Tailwater from upstream and nearby ditches
   c) Run-off or drainage water from adjacent ricefields
4. Frequency and interval of irrigation
5. Duration and timing of irrigation
6. Stream size of irrigation
7. Methods of irrigation
8. Availability, density and placement of on-farm channels and Structures

Thirty farmers who planted onions were interviewed starting on 5 April 1987. Six farmer-cooperators were identified. An ocular inspection of the project site was done to facilitate documentation.

Three locations within the UTRIS were selected as study site; these were in Tayabo (upstream), Sibut (midstream) and Calaocan (downstream).

Research Results

Farmers practiced two methods of land preparation: the *dayos* or raised bed and the *latag* or mulched bed methods. The *dayos* method entails three to four plowing and three to four harrowing operations while the *latag* method requires no tillage at all, or, at most, only one plowing and one rotovating operation. Land preparation started as early as November 1987.

Among the upland crops planted were onions, tomato, peanut, eggplant, bush bean, okra, sweet potato, squash and *patola*. However, most farmers planted onions during the dry season. Table 1 summarizes the production parameters of onion.

Farm size ranged from 0.02 to 1.0 hectare.

Farmers obtained water from the main and supplementary farm ditches. Water was not obtained from nearby paddies planted to rice because the elevation of the fields planted to non-rice were higher than the rice fields. There were no seepage, run-off nor drainage water from the adjacent rice fields. Likewise, there was no tail-

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Table 1. Production parameters of onions. UTRIS 1986/87 drv season.

Site	Sample No.	Area (ha)	Seed (kg/ha)	Variety	Hill and row spacing (cm)	Method of Land Prep.	Yield (t/ha)
Calaocan downstream	1	0.50	1.0	Tanduyong		latag	10.0
	2	0.05	4.0	White	14x14	latag	33.0
	3	0.045	11.0	Batanes	14X14	latag	12.7
	4	0.045	11.0	Batanes	15x15	dayos	15.6
	5	0.05		Tanduyong	10X10	latag	5.8
	6	0.019		Tanduyong	10X10	latag	26.3
	7	0.20	8.0	Batanes		latag	3.0
	8	0.15	5.0	Batsinga		latag	2.7
	9	0.25	9.0	Batsinga	10X10	latag	2.4
	10	0.10	10.0	Tanduyong	15X15	latag	4.5
Sibot midstream	1	0.25	4.0	Y. Granex	14X14	dayos	17.6
	2	0.50	4.0	Red Creole	14x14	dayos	25.0
	3	I.00	8.0	Red Creole	14X14	dayos	7.1
	4	0.067		Y. Granex	10X10	dayos	34.3
	5	0.10		Y. Granex	10X10	dayos	32.0
	6	0.15	6.0	White		latag	13.3
	7	0.15	5.0	Y. Granex		latag	13.3
	8	0.20	7.0	White	10X10	dayos	35.0
	9	0.30	8.0	Y. Granex	10X10	latag	15.0
	10	0.05		Red Creole		dayos	34.0
Tayabo upstream	I	0.06	3.3	Red Creole	15X15	dayos	19.4
	2	0.125	4.0	Y. Granex	15X15	latag	14.I
	3	0.15	6.6	Batanes	15x15	latag	18.4
	4	0.05	5.0	Y. Granex	10X10	latag	15.8
	5	0.06	6.0	Y. Granex	10X10	latag	16.3
	6	0.04		Red Creole	11X11	dayos	25.0
	7	0.20	4.0	White	10X10	latag	25.0
	8	0.25	6.0	White		latag	24.4
	10	0.10	5.5	Y. Granex		latag	11.0
		0.15	4.0	Y. Granex	15X15	davos	11.3

water from the upstream nor nearby ditches that could be a significant source of irrigation water for any crop.

Farmers practiced border irrigation to irrigate their upland crops. Paddy fields were rectangular (about 20X30 meters on the average) and were surrounded with dikes.

Irrigation application ranged from seven to eight for the dayos method and from four to five for the latag method (Table 2). Irrigation time ranged from 25-68 min (depending on the size of area irrigated) for the ***dayos*** method and from

Table 2. Total water applied. water use and vield. UTRIS.

Farm Location	Variety	Method of Land Preparation	Area (m^2)	No. of Irri-gation	Total Water Applied (mm)	Water Use (mm/day)	Yield (t/ha)
Tayabo	Y. Granex	Latag	471	5	446	5.2	17.42
Tayabo	Y. Granex	Latag	641	5	423	4.8	15.54
Sibot	Y. Granex	Dayos	1,298	7	329	3.6	26.60
Sibot	Y. Granex	Dayos	671	8	502	7.4	37.04
Calnocan	Tanduyong	Latag	546	4	505	5.6	5.49
Calaocan	Tanduyong	Latag	386				14.24
Averaee					441	5.3	19.39

Table 3. Cultural practices in onion production of the six farmer-cooperators, UTRIS, 1987/88 dry season.

	Midstream		Downstream		Upstream	
Farm Location	Sibot	Sibot	Calaocan	Calaocan	Tayabo	Tayabo
Land Preparation:						
Date	25 Nov 1987	26 Dec 1987	23 Nov 1987	14 Nov 1987	20 Nov 1987	25 Nov 1987
Method	***Dayos***	***Dayos***	***Latag***	***Latag***	***Latag***	***Latag***
No. of plowing	3	4	None	1	None	None
No. of harrowing	3	4	None	1	None	None
Onion Variety:	Yellow Granex	Yellow Granex	Tanduyong	Tanduyong	Yellow Granex	Yellow Granex
Date of Seeding:	1 Dec 1987	31 Dec 1987	28 Nov 1987	16 Nov 1987	25 Nov 1987	29 Nov 1987
Field Size (m2):	670.65	1,298.13	546.39	386.23	470.67	647.40
Transplanting Date:	25 Dec 1987	24 Jan 1988	26 Dec 1987	16 Dec 1987	24 Dec 1987	27 Dec 1987
Hill and Row Spacing (cm)	10×10	10×10	10×10	11×11	11×11	11×11
Fertilizer:						
Kind	16-20-0	12-12-12	14-14-14	12-12-12	a) 21-0-0-(24) b) 14-14-14	a) 14-14-14 b) Urea
Method of application	Broadcast	Broadcast	Broadcast(Basal)	Broadcast(Basal)	Broadcast	Broadcast
Rate (kg/ha)	335	310	414	378	a) 189 b) 238	a) 140 b) 117
Date of application	6 Jan 1988	4 Feb 1988	16 Jan 1988	8 Jan 1988	a) 6 Feb 1988 b) 21 Dec 1987	a) 26 Dec 1987 b) 23 Jan 1988
Weedicide:						
Kind	a) Machete b) Gould	a) Machete b) Gould	Machete	Machete	Machete	Machete
Date of application	a) 28 Dec 1987 b) 5 Jan 1988	a) 29 Jan 1988' b) 3 Feb 1988	29 Dec 1987	20 Dec 1987	27 Dec 1987	6 Jan 1988
Manual Weeding:	25-28 Jan 1988	None	None	None	28 Jan 1988	25 Jan 1988 and 11 Feb 1988
Insecticide/ Pesticide:						
Kind	Mytox (02/05/88)	a) Parapest b) Supreme Foliar	Follidol	a) Supreme 5 b) Supreme Foliar	Parapest	None
Date of application	5 Feb 1988	a) 4 Feb 1988 b) 15 Feb 1988	30 Jan and 10 Feb 1988	a) 15 Jan 1988 b) 1 Feb 1988	7 Feb 1988	
Fungicide:						
Kind	None	Supreme 5	None	None	Supreme 5	Supreme 5
Date of avvlication		14 Feb- 1988			6 Feb 1988	10 Feb 1988

19-63 min for the *larag* method. Irrigation water was applied every three to four weeks for the *larag* method and one to two weeks for the *dayos* method.

Inflow stream size ranged from 10-35liters per second (lps) for the *dayos* method and from 8-50 Ips for the *larag* method depending on the size of area irrigated.

On-farm channels and structures used by the farmers were the main farm, supplementary farm, intercepting or seepage, head, paddy field, and drainage ditches; paddy dikes; checks; and intake and offtake structures (Figures 1 to 5). On-farm structures were usually made of available indigenous materials such as mud, shrubs, weeds, plastic and small tree branches.

The length of the main farm ditch, from the turnout to the farm intake, ranged from 101-452 meters depending on location. Each onion plot or field was provided with a drainage ditch and one to three intakes and/or offtake structures. Two to four checks were also constructed from the main farm ditch to the field whenever irrigation was applied.

Hill and row spacings ranged from 10-15 cm. Fertilizer was applied by broadcasting in either basal or split amounts at the rate of 117-415 kg/ha and using 16-20-0, 21-0-0-(24), Urea, 14-14-14, and 12-12-12.

Manual weeding was done 30-35 days after transplanting. Weedicides were also applied 3-10 days after transplanting.

The onion crop was harvested 86-92 days after transplanting. Table 3 shows the cultural practices in onion production of the six farmercooperators.

Yields ranged from 15-17 t/ha under the *larag* method using Yellow Granex and 5-14 t/ha using *tanduyong*; under the *dayos* method, yields ranged from 26-37 t/ha using Yellow Granex (Table 4).

Summary and Recommendation

Cultural practices varied among the six farmercooperators. Considering yield as index, the cultural practice that was followed by farmers in Sibut is recommended. Although laborious and costly, the high yields can still compensate for the costs incurred.

On-farm channels and structures were made by the farmers themselves out of available indigenous materials in the field.

It is perceived that the first objective of the study was already fulfilled. The second objective was not met because the start of the study was later than expected. Adjustment of the calendar of activities was then requested as reflected in the April-June 1987 Progress Report of this study. It is felt however, that satisfying the second objective may no longer he as important as conceived before. Instead, the following changes on the activities to be pursued are proposed.

The title of this study may be changed to "System Water Management Practices for Diversified Crops", the main objective of which is to document and analyze the current system water management for diversified crops during the dry season. The activities will focus on the determination of the available water supply from the diversiondamduring the dry seasonand the actual area devoted to rice and non-rice crops on a system-wide scale. The water use of onion will be based on the result of this study, while the water use of other crops may be estimated from literature. Therefore, it can he determined whether or not the available water supply from the river is being fully utilized, as well as whether or not expansion of the irrigated area during the dry season is possible.

Table 4. Yield of onions under the *latag* and *dayos* methods of land preparation, UTRIS, 1987/88 dry season.

Variety	Latag		Dayos	
	Yield	Fertilizer	Yield	Fertilizer
Yellow Granex	17.42	428	37.04	646
	15.54	256	26.60	310
Average	16.48		31.82	
Tanduyong	5.49	414		
	14.24	378		
Average	9.86			

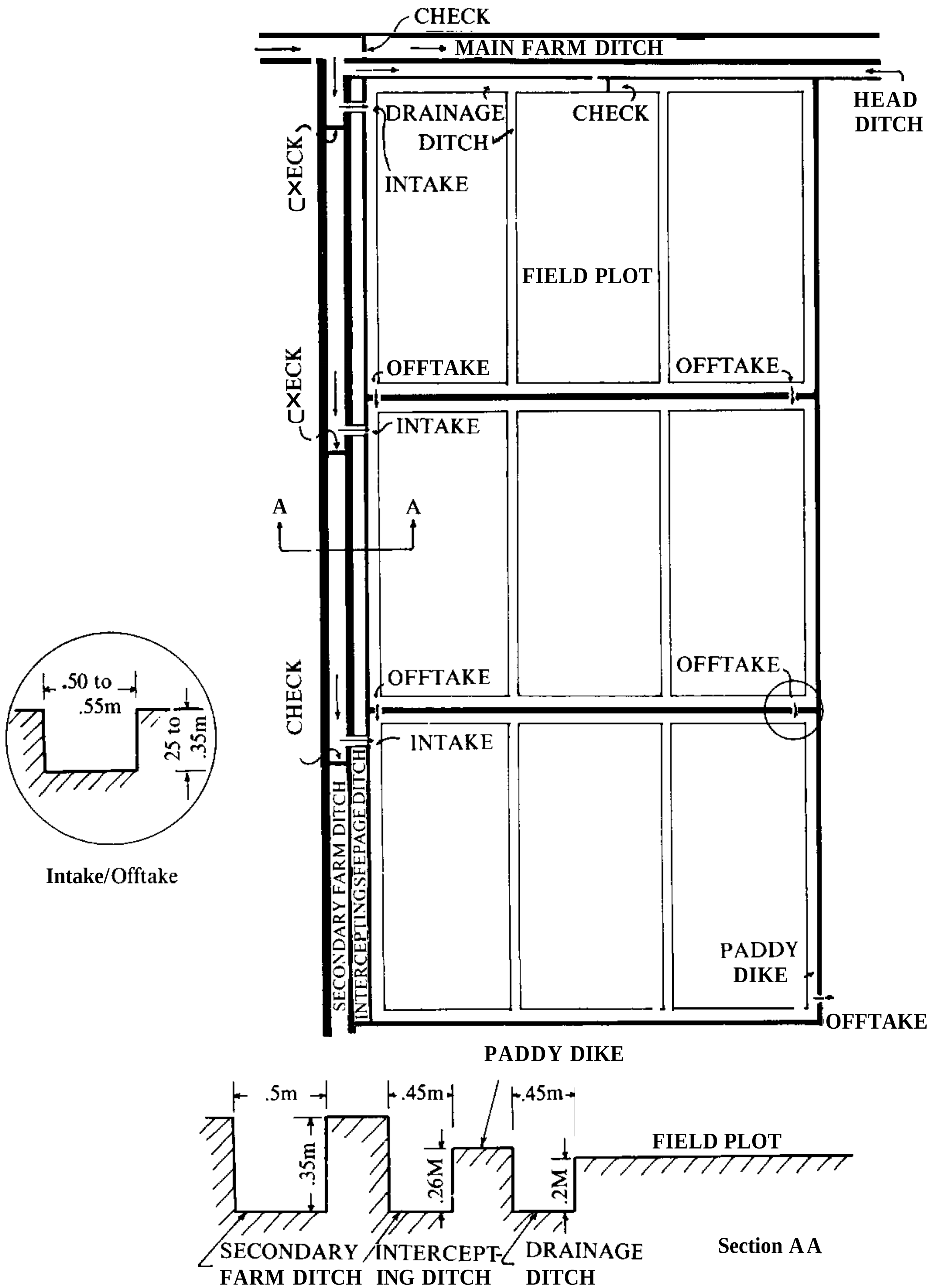
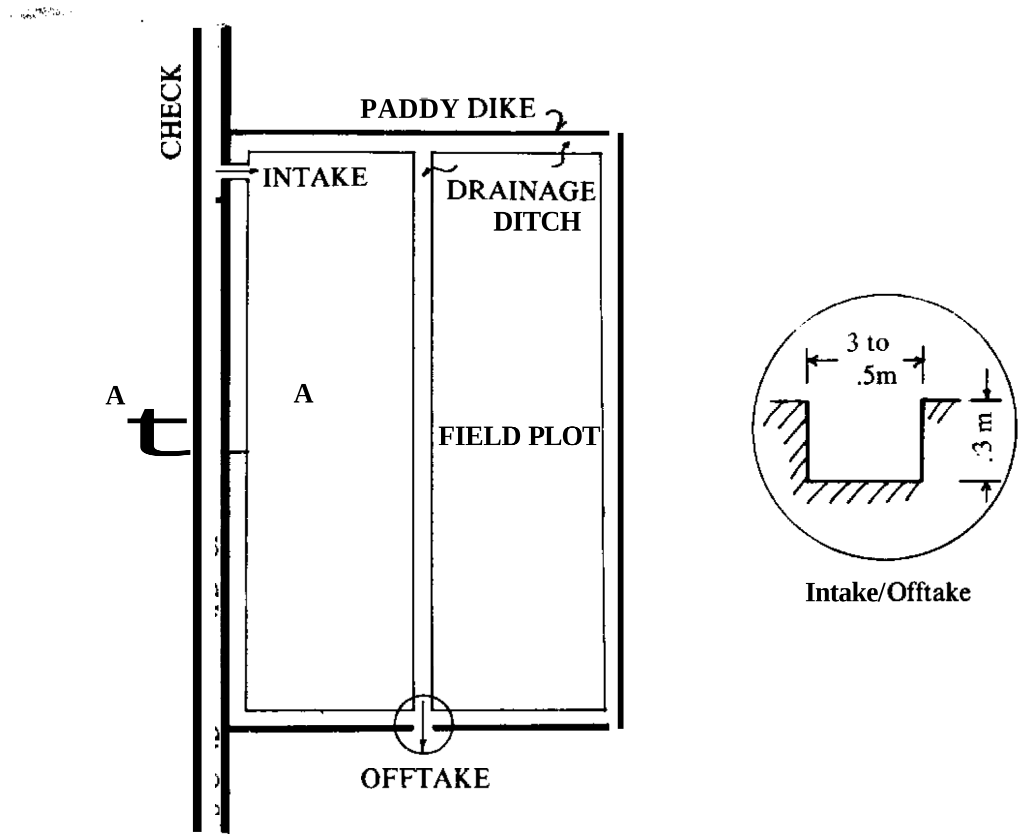
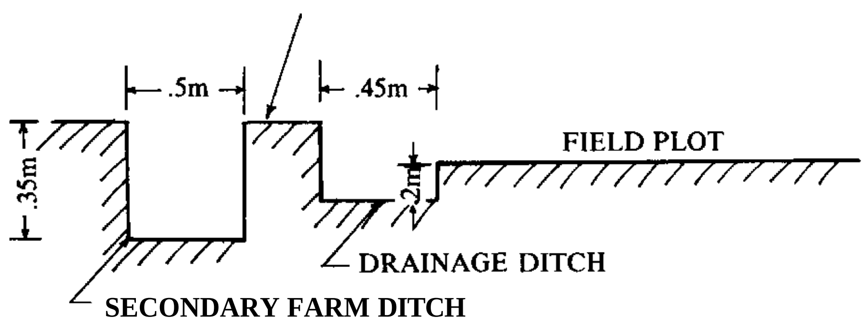


Figure 1. On-farm chnnels and structures used in growing onions.
Locations: Tayabo, Farmers: M. Biluan, Sample plot area=470.67 m^2
(Drawn not to scale).



Intake/Offtake



Section AA

Figure **2. On-farm channels and structures used in growing** onions.
Location: Tayabo, Farmers: M. Cabanayan, Sample Plot area=647.4 m2 (Drawn not to scale).

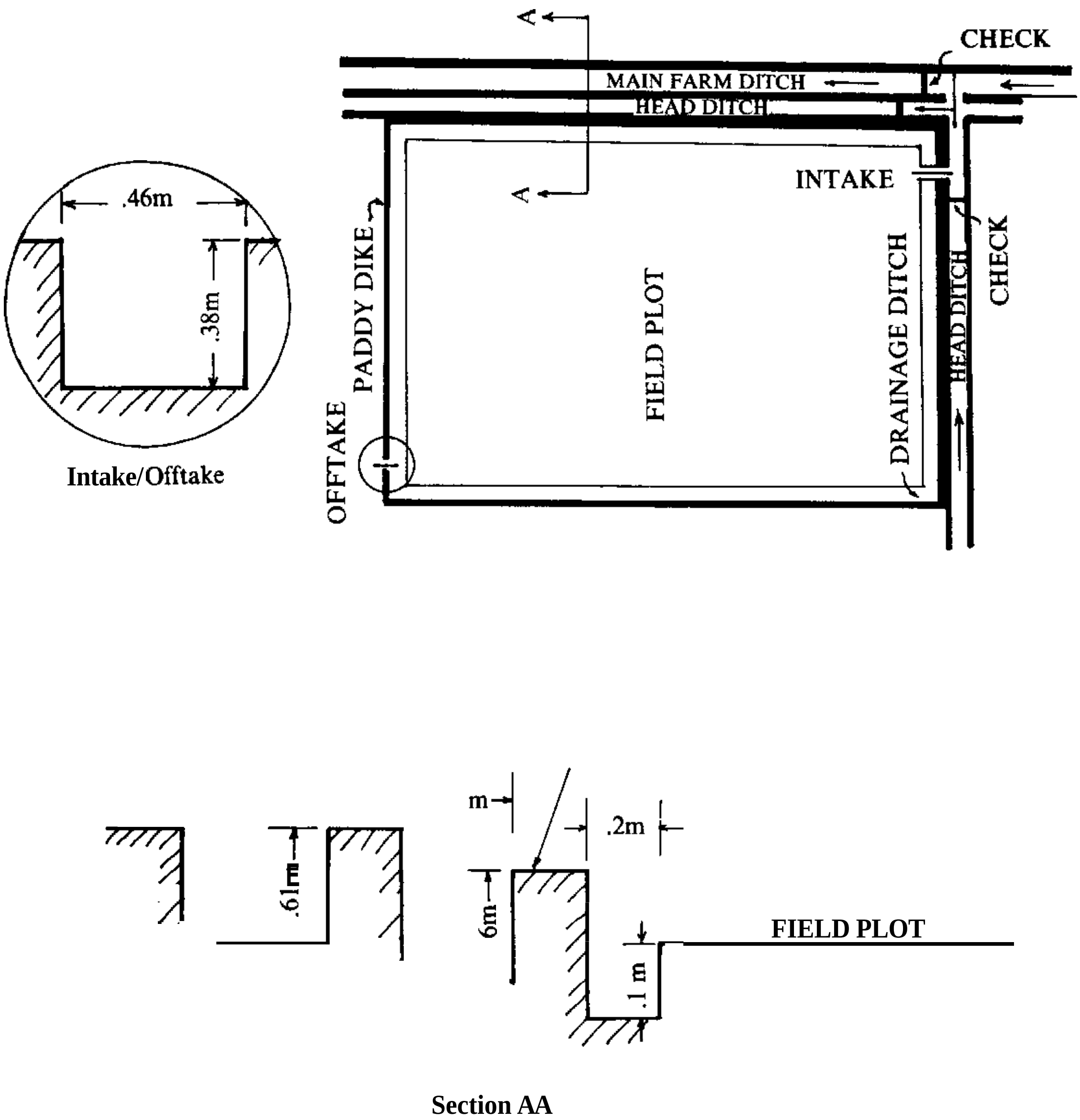
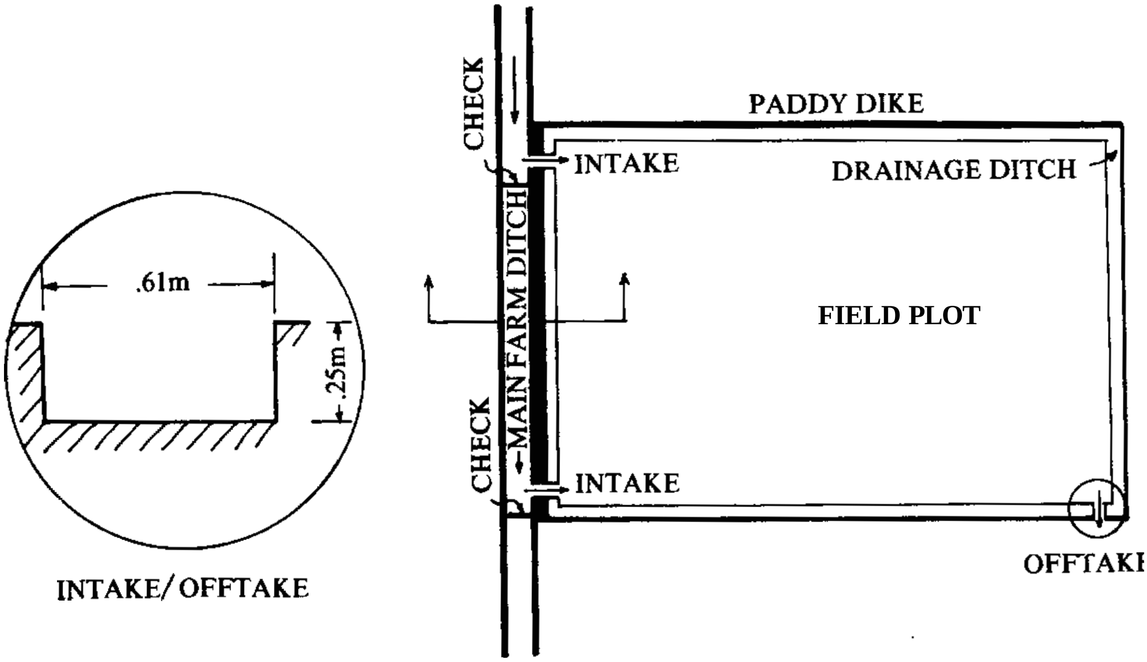


Figure 3. **On farm channels and structures used in growing onions. Location: Sibot, Farmer R. Satulan, Sample plot area=670.7 m2 (Drawn not to scale).**



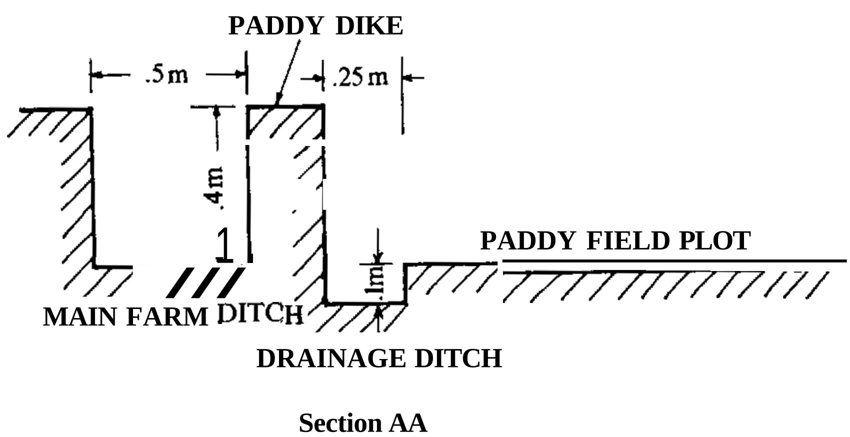


Figure 4. On-farm channels and structures used in growing onions. Location: Sibot; Farmer: B. Toralba; Sample plot area=1,298.1 m^2 (Drawn not to scale).

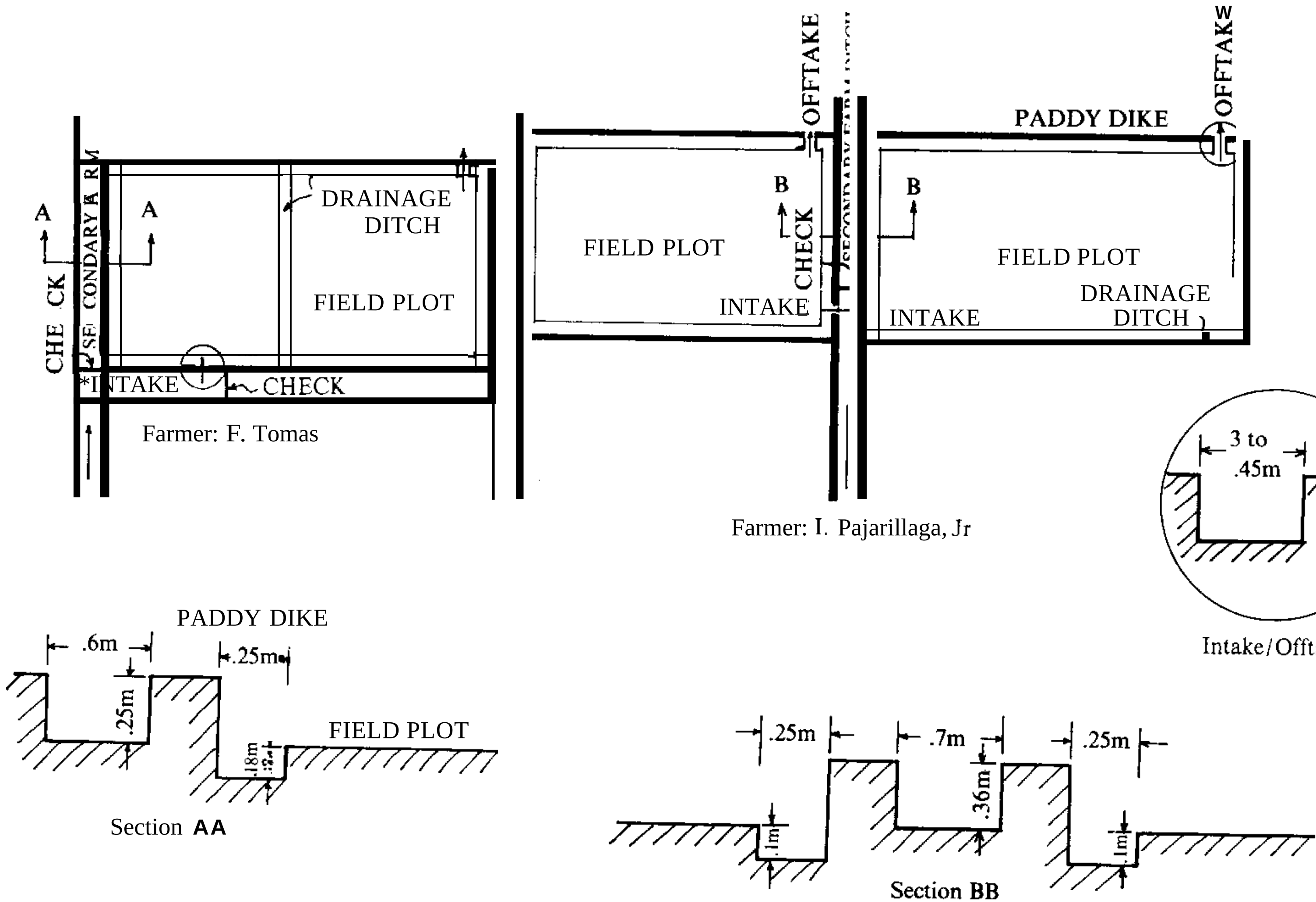


Figure 5. On-farm channels and structures used in growing onions.
Location: Calaocan, Farmers: F. Tomas and I. Pajarillaga, Jr., Sample plot area = **546.4** m^2 and 386.2 m^2 for F. Tomas and I. Pajarillaga, respectively. (Drawn not to scale)

On-farm Land Preparation Practices for Irrigated Diversified Crops

Miguel L. Aragon[1]

Introduction

Land preparation is the first among many cultural practices in rice-based cropping system. In irrigated areas, wetland tillage is the common practice of land preparation for rice production. This involves landsoaking and a series of tillage operations at or near saturation soil moisture content or while the soil is under standing water. In some areas however, land preparation varies depending on the crop to be grown, availability of water, soil texture, and resources available to the farmer. Unlike in irrigated double-rice cropping, timing of tillage operations is important in irrigated diversified cropping systems. The timeliness and quality of land preparation affect not only the growth and yield of rice but also those of the succeeding upland crops. This is because rice is grown under puddled soil condition and the soil has to be converted into dry, well-aerated condition to suit upland crops.

objectives

A study was conducted to document land preparation practices for irrigated diversified crops, particularly rice-onion cropping sequence. In general, the objective is to document the primary factors and their interaction which condition how farmers prepare land for irrigated rice during the wet season and for onion during the dry season. Special .attention is given to labor and power requirements for tillage operations, timeliness of land preparation, moisture regimes, provision for field channels, and other relevant factors.

Methodology

The study was conducted in seven locations in San Jose City, Nueva Ecija, served by the Upper Talavera River Irrigation System (UTRIS) during the 1987/88 cropping season. The sites were selected based on accessibility, location of the field, and the experience of farmers in crop diversification. Under diversified cropping system (rice-onion) four sites were chosen: two in Kaliwanagan (upstream), one in Tayabo (upstream), and one in Sibut (midstream). The sites chosen were representative of most farms in the study area based on interview and field surveys earlier conducted. Fifteen farmers in seven barangays of UTRIS, namely, Calaocan, Kaliwanagan, Kita-kita, Malasin, Manicla, Sibut and Tayabo were interviewed. On the other hand, three sites were selected as sites for double-rice cropping - one each in Tayabo, Malasin and Sibut.

Using a soil auger, surface soil samples (up to 15 cm depth) were collected from each site for analysis of soil physical properties. Particle size distribution using the hydrometer method was determined at the Department of Soil Science, Central Luron State University. Infiltration rate and water retention capacity were determined at the Soil and Water Analytical Laboratory, National Irrigation Administration (NIA), Muñoz, Nueva Ecija. The morphological characteristics of the four farms used for crop diversification in the study were described. Similarly, the soil used for double-rice cropping was also characterized.

Field visits and interviews with farmers were conducted to determine land preparation activities and farm labor and power requirements for land preparation for onion and rice production during the dry season. Temporary irrigation ditches, drainage canals and levees constructed were measured immediately after each field was prepared, ready for transplanting onion seedlings.

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The fanners had long been practicing crop diversification (rice-onion cropping pattern) ranging from 10-35 years. Farm size, however, was relatively small, from 0.66-1.5 hectares (Table 1). All fanners owned a water buffalo which was the main source of tillage power for land preparation. Generally, the availability of labor and power for land preparation was not a problem, especially in Barangays Kaliwanagan and Sibut where farmers practiced the *bayanihan* system.

Soils used for crop diversification were medium-textured - having sandy clay loam to clay loam texture (Table 2). Surface soil has a high moisture retention capacity and percolation rate. Soils used for crop diversification were characterized generally as welldrained and friable to slightly hard when wet. Morphological characteristics of the soil were classified either as Entisol or Inceptisol.

Farmers practiced dryland plowing when preparing land for rice production during the wet season, i.e., the land was not soaked and primary tillage was done without standing water (Table 3). Plowing was accomplished in June and July as soon as water supplied was enough to wet the upper 15 cm plow layer either from rain or irrigation water.

Table *1*. Farmers' profile and farm information, UTRIS.

Sample Farm	Farmer	Tenurial System	Water Buffalo Ownership	No. of Years in Farming	Farm Area (ha) Rice-rice	Rice-onion	Total	Location
				Rice-onion Cropping Pattern				
I	Saturnino M. Brillo	Owner	Owner	I5	0.20	0.80	1.00	Kaliwanagan
2	Jaime R. Casambre	Leaseholder	Owner	10	0.50	1.25	1.75	Kaliwanagan
3	Alvaro C. Serra	Owner	Owner	35	0.04	0.66	0.70	Tayabo
4	Benjamin B. Toralba	Leaseholder	Owner	31	0.00	1.50	1.50	Sibut
				Rice-Rice Cropping Pattern				
I	Wilfredo R..Casambre	Owner	Owner	10	1.50	0.00	1.50	Tayabo
2	Venancio C. Ordonio	Leaseholder	Owner	10	I.00	0.00	1.00	Malasin
3	Gregorio B. Soriano	Leaseholder	Owner	15	1.20	0.25	1.45	Sibut

Table 2. Soil physical properties, UTRIS.

Sample Farm	Particle Size Distribution %Sand	% Silt	%Clay	Soil Texture	Moisture Retention Capacity (bar) 1/10	1/3	3	I5	Percolation Rate cm/hr
				Rice-Onion Cropping Pattern					
I	12	49	39	silty clay loam	30.18	22.01	14.86	9.75	0.26
2	28	35	37	clay loam	33.23	24.62	13.18	7.27	0.29
3	51	23	26	sandyclay loam	30.66	22.86	11.80	5.82	0.36
4	28	37	35	clay loam	29.55	22.85	12.02	7.03	0.27
				Rice-Rice Cropping Pattern					
I	16	36	48	clay	33.25	26.04	19.54	9.33	0.21
2	20	30	50	clay	31.66	23.33	16.51	8.50	0.09
3	28	26	56	clay	34.W	26.07	18.54	9.92	0.11

Table 3. Land preparation practices for rice production, UTRIS, 1987 wet season.

Sample Farm	Type of Primary Tillage	Land Soaking	Sowing	Plowing	First Harrowing	Second Harrowing	Trans-planting	Age of Seedlings
				Rice-Onion Cropping Parlern				
1	Dryland	None	June 16	July 2	July 10	July 15	July 16	30
2	Dryland	None	June 22	July I	July 9	July 23	July 24	32
3	Dryland	None	July 1	July 6	July 16	July 25	July 26	38
4	Dryland	None	June 23	June 23	July I2	July 19	July 25	27
				Rice-Rice Cropping Pattern				
1	Wetland	June 8-15	June 24	June 16	July 7	July 22	July 29	35
2	Wetland	July 22-23	July 16	July 23	July 30	August 9	August 10	24
3	Wetland	July 22-25	June 28	July 20	July 30	July 30	August 1	35

The farmers had varied land preparation practices from a puddled soil condition during the wet season into an upland, well-aerated soil condition for onion during the dry season (Tables 4a to 4d). Variations in land preparation practices were due to variations in method of planting, variety used, soil texture, and tillage levels.

Table 4a. Land preparation practices and labor and power requirements for land preparation for onion production, 1987/88 dry season.

Farmer: Saturnino M. Brillo
Yield 15.58 t/ha
Variety: Multiplier onion (Batanes)
Type of Planting: *Dayos*
Soil Texture: Silty clay loam

Original Size of Paddy: 1441 sq m'
Size of Lot: 307.47 sq m²
No. of Lots/Paddy: 4
Size of Plot: 15.45 sq m³
No. of Plots/Lot: 19
Distance of Planting
Between rows: 20 cm
Between hills: 11 cm

Day	Actual Date	Activity/Operation	Labor and Power Requirement: Labor (hr/ha)	Animal (hr/ha)
0	October 10	Focal date (rice harvest)		
20	October 30	First plowing	25	25
38	November 17	First flooding	5	0
49	November 28	First harrowing	25	25
51	November 30	Second harrowing	20	20
54	December 3	Construction of irrigation ditches and drainage canals	10	5
55	December 4	Second flooding	5	0
56	December 5	Transplanting		

'Length = 76.0 m; Width = 18.8 m
'Length = 16.3 m; Width = 18.8 m
'Length = 0.8 m; Width = 18.8 m

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Table 46. Land preparation practices and labor and power requirements for land preparation for onion production, 1987188 dry season.

Farmer: Jaime R. Casambre	Original Size Of Paddy: 646 sq m
Yield: 10.01 t/ha	Length = 34.4 m; Width = 18.75 m
Variety: Yellow Granex	Distance of Planting: 12 cm
Type of Planting: *Latag* (with mulch)	
Soil Texture: Clay loam	

Day	Actual Date	Activity/Operation	Labor and Power Requirement	
			Labor (hr/ha)	Animal (hr/ha)
0	November 18	Focal date (rice harvest)		
5	November 23	First plowing	35	35
6	November 24	First harrowing	25	25
12	November 30	Second harrowing	15	15
20	December 8	First flooding	5	0
26	December 14	Second plowing	20	20
28	December 16	Third harrowing	5	5
29	December 17	Construction of irrigation ditches and drainage canals	5	5
30	December 18	Second flooding	5	0
31	December 19	Mulching	25	0
32	December 20	Transplanting		

Table 4c. **Land** preparation practices and labor and power requirements for land preparation for onion production, 1987/88 dry season.

Farmer: Alvaro C. Serra	Original Size of Paddy: 1269 sq m[1]
Yield: 15.00 t/ha	Size of Lot: 368.48 sq m[2]
Variety: Yellow Granex	No. of Lots/Paddy: 5
	Size of Plot: 47.60 sq m[3]
Type of Planting: *Dayos*	No. of Plots/Lot: 7
Soil Texture: Sandy clay loam	Distance of Planting
	Between rows: 15 cm
	Between hills: 12 cm

Day	Actual Date	Activity/Operation	Labor and Power Requirement	
			Labor (hr/ha)	Animal (hr/ha)
0	October 17	Focal date (rice harvest)		
5	October 22	First plowing	25	25
21	November 7	First harrowing	10	10
28	November 14	First flooding	5	0
30	November 16	Second plowing	15	15
38	November 24	Second harrowing	10	10
44	November 30	Third harrowing	5	5
46	December 2	Construction of irrigation ditches and drainage canals	10	5
48	December 4	Second flooding	5	0
49	December 5	Transplanting		

[1]Length = 45.0 m; Width = 28.0 m

[2]Length = 13.2 m; Width = 28.0 m

[3]Length = 1.7 m; Width = 28.0 m

Table 4d. Land preparation practices and labor and power requirements for land preparation for onion production. 1987/88 dry season.

Farmer: Benjamin B. Toralba	Original Size of Paddy: 1945 sq m [1]
Yield: 12.00 t/ha	Sire of Lot: 972.52 sq m [2]
Variety: Red Creole	No. of Lots/Paddy: 2
	Size of Plot: 24.55 sq m [3]
Type of Planting: Dayos	No. of Plots/Lot: 31
Soil Texture: Clay loam	Distance of Planting
	Between rows: 9 cm
	Between hills: 8 cm

Day	Actual Date	Activity/Operation	Labor and Power Requirement	
			Labor (hr/ha)	Animal (hr/ha)
0	November 4	Focal date (rice harvest)		
3	November 7	First plowing	25	25
34	December 8	First flooding	5	0
38	December 12	First harrowing	10	10
40	December 14	Second plowing	20	20
42	December 16	Second harrowing	5	5
43	December 17	Construction of irrigation ditches and drainage canals	5	5
44	December 18	Second flooding	5	0

[1] Length = 57.0 m; Width = 34.1 m
[2] Length = 28.5 m; Width = 34.1 m
[3] Length = 0.7 m; Width = 34.1 m

In all farms, the farmers plowed their fields 3-20 days after rice harvest. The field was fallowed for two to four weeks to allow the growth of weeds. The field was then flooded twice before transplanting - first flooding, either before the first plowing or second harrowing to reduce big clods to smaller ones and the second flooding, either after the second or third harrowing, or just after the irrigation ditches and drainage canals are constructed, or one day before transplanting. Taking the date of rice harvest as the focal date, land preparation was completed within eight weeks.

For the *latag* method of planting (with mulch), tillage operations consisted of two plowing and three harrowing operations while under the *dayos* method (without mulch), one to two plowing and two to three harrowing operations were needed. Regardless of the land preparation practices of farmers, planting method, variety used, and soil texture, the yield of onion ranged from 10-15 t/ha.

A hectare of irrigated farm for onion production can be prepared by employing a labor input of 75-135 hr/ha and a power input of 65-105 hr/ha or a total of 140-245 hr/ha (Table *5).* Labor and power inputs include those for primary and secondary tillage, flooding the field twice, construction of temporary levees, drainage canals, and irrigation ditches, and mulching for the *latag* method of planting.

In summary, the results of this study indicate that the primary factors involved in the conversion of puddled lowland to upland soil conditions are: (1) familiarity with the rice-non-rice production process, (2) the relatively smaller farm sue for upland crop production, (3) availability of labor and power, and (4) presence of medium textured soils and practices to control weeds and promote better root growth.

Table 5. **Average labor and power requirements for land preparation for onion and rice production. UTRIS. 1987/88 dry season.**

Sample Farm	Soil Texture	Method of Planting/Tillage	Labor and Power Requirement (hr/ha) Labor	Power	Total
		Onion Production			
1	Silty clay loam	*Dayos*	95	75	170
2	Clay loam	*Latag*	140	105	245
3	Sandy clay loam	*Dayos*	105	85	190
4	Clay loam	*Dayos*	75	65	140
		Rice Production			
1	Clay	Wetland	105	105	210
2	Clay	Wetland	85	85	170
3	Clay	Wetland	85	85	170

Profitability Analysis of Rice and Onions Planted During the Dry Season Under Irrigated Conditions

Eduardo G. Marzan, Jr.[1]

Introduction

Farmers plant crops that are adapted to the area and have high market potential. Crops of which farmers are familiar with the production technologies are also grown. In crop production, farmers also prefer to plant crops that result in more profit with less risk involved.

A study was conducted in the area covered by the Upper Talavera River Irrigation System (UTRIS) in Nueva Ecija to compare the profitability of onions and rice planted during the dry season. The study aimed to:

1. Compare the profitability of rice and onion planted during the dry season under irrigated conditions;
2. Determine farmers' reasons for planting rice and onions and the factors which they consider in selecting upland crops;
3. Identify sources of funds for farming operations; and
4. Determine the problems encountered by farmers in rice and onion production.

Methodology

The study covered the 1986/87 and 1987/88 dry seasons. Respondents were farmers who planted onions and rice at the upstream and midstream of the **UTRIS** main canal. Fifty onion growers and 10 rice farmers as well as 80 onion growers and **28** rice farmers were interviewed during the first and second dry seasons, respectively.

In the first survey, 10% of the total onion growers were randomly selected and 10 rice farmers were interviewed for comparison. In the second survey, 80 onion growers and 28 rice farmers were randomly selected from the upstream and midstream parts of the canal. The list of farmers was obtained from the National Irrigation Administration (NIA).

One-shot interviews were conducted during the first survey (May-June 1986). The second survey was conducted m two parts: the first part was conducted immediately after land preparation (December 1987 for onions and January 1988 for rice); the second part was conducted after the produce were marketed (May 1988 for onions and June 1988 for rice). The same questionnaire-interview schedule was used in both surveys. About **24%** of onion growers and **22%** of rice farmers in the first survey served as respondents in the second survey.

Frequency counts and percentages were used in summarizing the data; mean costs and return and profitability ratios were used in the analysis.

Research Highlights

Onion production was found more profitable per unit area than rice farming (Table 1). However, the price of onions fluctuated during and between seasons resulting to larger variations in income. Although the price of palay increased, yield decreased during the second dry season. Production cost per hectare did not differ for both crops. However, cost structure varied, i.e., onion production was characrerized as input-oriented during the 1986/87 dry season and labor-oriented during 1987/88 dry season. For rice, the cost of inputs did not differ in either dry seasons but became labor-intensive during the second dry season because of increase in labor utilized to irrigate the crop when water became scarce.

All respondents aimed at maximizing their profit. Farmers planted upland crops that will provide the highest returns (Table **2).** Water **was** not considered a primary factor in deciding what crops to plant except for onion growers during the

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Table 1. Comparative profitability per hectare between onions and rice, UTRIS, 1986/87 and 1987/88 dry seasons.

Items	1986/87		1987/88	
	Onion	Rice	Onion	Rice
Total yield (kg)	7,967	3,925	7,157	3,211
Total value (₱)	21,669	11,971	46,023	11,237
Average price (₱)	2.73	3.05	6.49	3.23
Total variable cost (₱)	18,217	1,909	15,087	2,973
Total fixed cost (₱)	11,225	7,726	15,600	6,970
Total cost (₱)	29,442	9,636	30,687	9,944
Net income (loss):				
above variable cost	3,452	10,061	30,937	8,264
above all costs	(7,772)	2,335	15,336	1,293
Net cash income (loss)	(451)	3,650	19,638	192
Break-even price	3.70	2.46	4.29	3.10
Return on investment (%)		32	52	14

Table 2. Factors influencing the choice of crop and area planted, UTRIS, 1986/87 and 1987/88 dry seasons.

	1986/87				1987/88			
	Onion (n=50)		Rice (n=10)		Onion (n=80)		Rice (n=28)	
	Average Rank[a]	%[b]	Average Rank	%	Average Rank	%	Average Rank	%
Choice of crop								
Perceived to provide highest returns	1.32	88	2.20	100	1.93	85	1.75	43
Previous experience	2.66	88						
Technology known to farmers	2.70	86					2.40	54
Ready market			2.71	70	2.93	88		
To meet rice requirement			2.89	90			1.84	89
Availability of water					2.88	64		
Area Planted								
Availability of planting materials and other inputs	1.31	52	1.67	90				
Sue of market	2.12	50	2.20	100	2.11	100	2.00	82
Previous experience	2.49	98			2.56	80	2.75	71
Availability of water			2.50	100	2.66	98	1.72	89

[a]Most important = 1, less important = higher value of rank.
[b]Proportion of respondents reporting.

1987/88 dry season. Water was considered crucial then due to drought experienced during the 1987 wet season. Rice farmers planted rice mainly to meet their own food requirement.

The size of the area planted to onions and rice are based on the size of the market. Availability of water; which is a major factor considered by rice farmers during the second dry season also determined area planted to onions and rice.

Non-institutional sources of credit were preferred by onion growers while rice farmers used their own savings to finance their farm operations (Table 3). A relatively larger portion of credit was

Table 3. Credit and marketing information, UTRIS, 1986/87 and 1987/88 dry seasons.

Factors	1986/87 Onion (n=50)	1986/87 Rice (n=10)	1987/88 Onion (n=80)	1987/88 Rice (n=28)
	Percent			
Credit				
Sources of loans				
Own savings	36	60	48	68
Neighbors/friends	28		22	
Relatives	20	20	12	18
Buyers/merchants		20		7
Banks			14	
Amount utilized for:				
Farm operation	70	21	95	83
Non-farm expenditures	30	79	5	17
Marketing				
Common outlets				
Local market buyers	62		72	72
Exporters	34		16	
NFA		50		
Middlemen/viajeros		40		
Wholesalers				16
Reasons for preference				
Offered highest price	38		50	64
Paid in cash	40	50		
Regular buyer		50		12
Provided seeds			21	
Mode of payment				
Cash	98	90	96	100
Installment	4		I	4
Mode of selling				
Picked-up	96	30	95	12
Delivered	4	50	2	88
Combination		10		

allocated for farm expenditures, except for rice farmers interviewed during the 1986/87 dry season.

The marketing practices of onion and rice fanners were the same. Most of them sold their produce to local buyers who offered the highest price (Table 3). More than 90% of the farmers were paid in cash for their produce. Onions were picked up either at the farm or at the fanner's house while rice was delivered to the buying center. Onions were picked-up because of their perishable nature; thus, they have to be disposed immediately.

Farmers encountered more economic than technical problems. Production-related problems were lack of capital and high cost of inputs (Table 4). Inadequate water supply was more of a problem encountered by rice farmers than by onion growers; onions required lesser amount of water than rice. There were less postharvest-related problems because farmers sold their produce immediately after harvest or used their produce as payment for their loans. Marketing problems were low prices and inadequate market outlets.

Profitability analysis showed that low prices were more of a perceived problem since the break-even prices were generally lower than actual prices. Results imply that farmers aim to maximize profit in spite of limited production.

Table 4. Production, marketing and credit problems encountered by farmers under UTRIS, 1986/87 and 1987/88 dry seasons.

	1986/87				1987/88			
	Onion (n=50)		Rice (n=10)		Onion (n=80)		Rice (n=28)	
	Average Rank[a]	%[b]	Average Rank	%	Average Rank	%	Average Rank	%
Production								
Attack of pests and diseases	1.77	52	1.70	100			2.28	32
Lack of capital (cash)	2.32	76	3.70	70	1.20	38	1.78	32
High cost of chemicals	4.31	52			2.15	75	1.77	19
Inadequate water supply	3.26	76	1.90	100	3.33	38	1.93	50
Lack of seeds					1.63	14		
Post-harvest								
Lack of storage facilities	1.48	50						
Lack of hauling facilities	1.70	40						
High rental of threshers			1.00	30				
High cost of drying			2.00	40				
Lack of drying facilities			2.00	70			1.50	7
Marketing								
Low prices	1.26	86	1.22	90				
Lack of marketing outlets	2.04	52	2.00	90				
Lack of grading and standardization	3.12	50	3.50	80				
Existence of market tie-ups	3.79	38					1.00	25
Delayed payment							1.50	14
Credit								
Immediate payment needed after harvest	1.88	68	2.70	100	1.46	35	1.40	18
High interest rates	2.21	48	1.80	100	1.94	21	1.00	7
Price paid by lenders is lower than current price	2.62	42	3.50	100	-	-	-	-
Collateral required			2.40	100	-	-	-	-

[a]Most problematic = 1, less problematic = higher value of rank
[b]Proportion of respondent reporting.

Optimum Farm Ditch Density for Irrigating Diversified Crops

Carlos M. Pascual, Arturo N. Francisco
and Gregorio C. Simbahan [1]

Abstract

Regression models were developed to determine the optimum farm ditch density for irrigating diversified crops. Size of turnout service area, shape factor, orientation of main farm ditches, average farm size, and farms with direct access to farm ditches were the physical factors that exhibited significant effects on the length of farm ditches. Optimum farm ditch density in two study sites had an average of 100 meter/ha, regardless of size of turnout service area. Since models are subjective, physical and field observations have to be employed.

Preliminary results of this study indicate the need for providing on-farm facilities if dry season diversified cropping is to be undertaken in gravity-type rice-based imgation systems.

Introduction

Farm ditches are terminal facilities, densities of which are expressed in linear length per hectare and estimated in general component studies of existing irrigation systems (Wickham and Valera, 1976). Farm ditches from 10 to 100 meter/ha were found limiting in different areas. A joint IRRI-NIA study (1984) determined the optimum turnout service area for irrigated rice in two gravity-type irrigation systems. Moya (1985) found that terminal facilities like farm ditch density influenced the allocation and uniform distribution of water in gravity-type systems serving rice. However, the relationship of farm ditch density with some physical water control parameters that dominate the use of water in irrigated fields planted to diversified crops is not yet well understood. This is especially true where irrigation flows from the farm ditches cause waterlogging or are inadequate, hence partial changes have to be made most especially in irrigating diversified crop. Tahbal, et al. (1983) found that terminal facilities like farm ditches were affected adversely, if inappropriately located.

Imgated diversified croplands in the Ilocos Region are small and fragmented. Also, overcrowding of farms at the turnout service areas coupled with high degree of land utilization are the main sources of conflict among farmers. Svendsen (1985) characterized the building and destroying tertiary-level farm ditches as hysteresis and considered this an inefficient approach to the design process.

Therefore, irrigation planners must provide adequate on-farm facilities to avoid possible conflicts among farmer-irrigators. There is then a need to understand the intensity of facilities that will provide an efficient water allocation and distribution.

Objectives

The study aimed to determine the optimum farm ditch density for irrigating diversified crops. It also aimed to determine the how physical factors of turnout service area affect the total length of farm ditches.

Study Sites

The study was conducted under two irrigation systems in Luzon:

Laoag Vintor River Irrigotion System *(LVRIS).* LVRIS is one of the eight imgation

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systems under the llocos Norte Irrigation Systems (INIS) in the province of llocos Norte. The system is a run-of-the-river type serving 2377 hectares.

Upper Talavera River Irrigation System (UTRIS). UTRIS is also a run-of-the-river type irrigation system which is served by a dam in Tayabo, San Jose City, Nueva Ecija. It is part of the Upper Pampanga River Integrated Irrigation System (UPRIIS). During the dry season, only about 500 hectares are programmed for diversified crops.

Methodology

Selection *of* turnout service area. Sample turnout service areas (TSAs), lengths of which are oriented either parallel or perpendicular to the lateral canal, were used as units for observation and analysis. Physical engineering survey was done at selected turnouts in each system that were partially or fully planted to diversified crops during the dry season. TSA's selected were representative of the head, middle, and tail sections of the irrigation systems.

Determination *of physical factors* and analysis. An engineering field survey was conducted at each sample TSA. Boundaries served by each turnout were properly delineated. The following were determined at each TSA. total service area (SA) delineating the area planted to rice (R) and non-rice crops (NR) onspecific farm plots; orientation and layout of main farm ditches (MFD's) and supplementary farm ditches (SFD's); main farm ditch gradient (MFDg); general land slope (GLs); average farm size (FSa); shape factor (SF); and percent of farm with direct access to the farm ditches (PF).

To evaluate the effects of the TSA physical variables on farm ditch length, multiple linear regression analysis was used. The functional relationship was expressed as:

$$FDL = f(Or, MFDg, GLs, R, NR, SA, FSa, SF, PF)$$

where:
FDL = farm ditch length, (meter);
Or = orientation of main farm ditch to supply canal (dummy variable, equal to zero when MFD is parallel to lateral canal or equal to one when it is perpendicular);
MFDg = main farm ditch gradient, (%);
GLs = general land slope, (%);
R = rice farm plots, (%);
NR = non-rice farm plots, (%);
SA = effective turnout service area, (ha);
FSA = average farm size, (ha);
SF = shape factor, (m/m); and
PF = percent of farms with direct access to farm ditches, (%).

The explanatory power of the model developed was tested using the F-statistic and the significance of each regression coefficient was tested using the T-statistic.

Results of the physical survey were drawn into scale to visualize the physical factors at each TSA.

Results and Discussion

Laoag Vintar River Irrigation System (LVRIS)

The LVRIS network consists of a 27.5-km main canal. It has seven main laterals and five sub-laterals. The total canal length is 72.98 km. There are about 396, 30-cm diameter, single-gated operational turnouts serving the command area (Table I). Thirty-five percent of these turnouts are in Division IV, where most diversified crops are planted. Forty-seven TSA's were selected within irrigation canals scheduled for irrigating diversified crops during the dry season.

Table 1. Distribution of turnouts in each division of LVRIS, 1987/88 dry season.

Division	Canal Section	No. of Turnouts	% of Total Turnouts	Service Area (ha)
I	Main canals 1-5, lat A, B, E and G	108	27	658
II	Main canals 6-8, lat H, G-1	75	19	685
III	Lat H	16	19	381
IV	Lat F, sub-lat F-lc, F-ld	137	35	653
TOTAL		396	100	2371

Physical Factors and Regression Models. A multiple linear regression analysis was used to evaluate the relationship between physical features of TSA (independent variables) and farm ditch length (dependent variable) to determine the optimum farm ditch density used in irrigating diversified crops.

Five regression models were developed (Table 2). Regression analyses of these models show that physical factors such as size of turnout service area (SA), shape factor (SF), farm size (FSa) and farms with direct access to farm ditches (PF) significantly influenced the farm ditch length (FDL).

Individual effects show that turnout service area (SA) and shape factor (SF) significantly affected farm ditch length (Table 2, Model la): both having positive coefficients. The model show that the narrower the farm was, the longer were the farm ditches. Results were consistent with field observations on long and narrow TSA (Figure I).

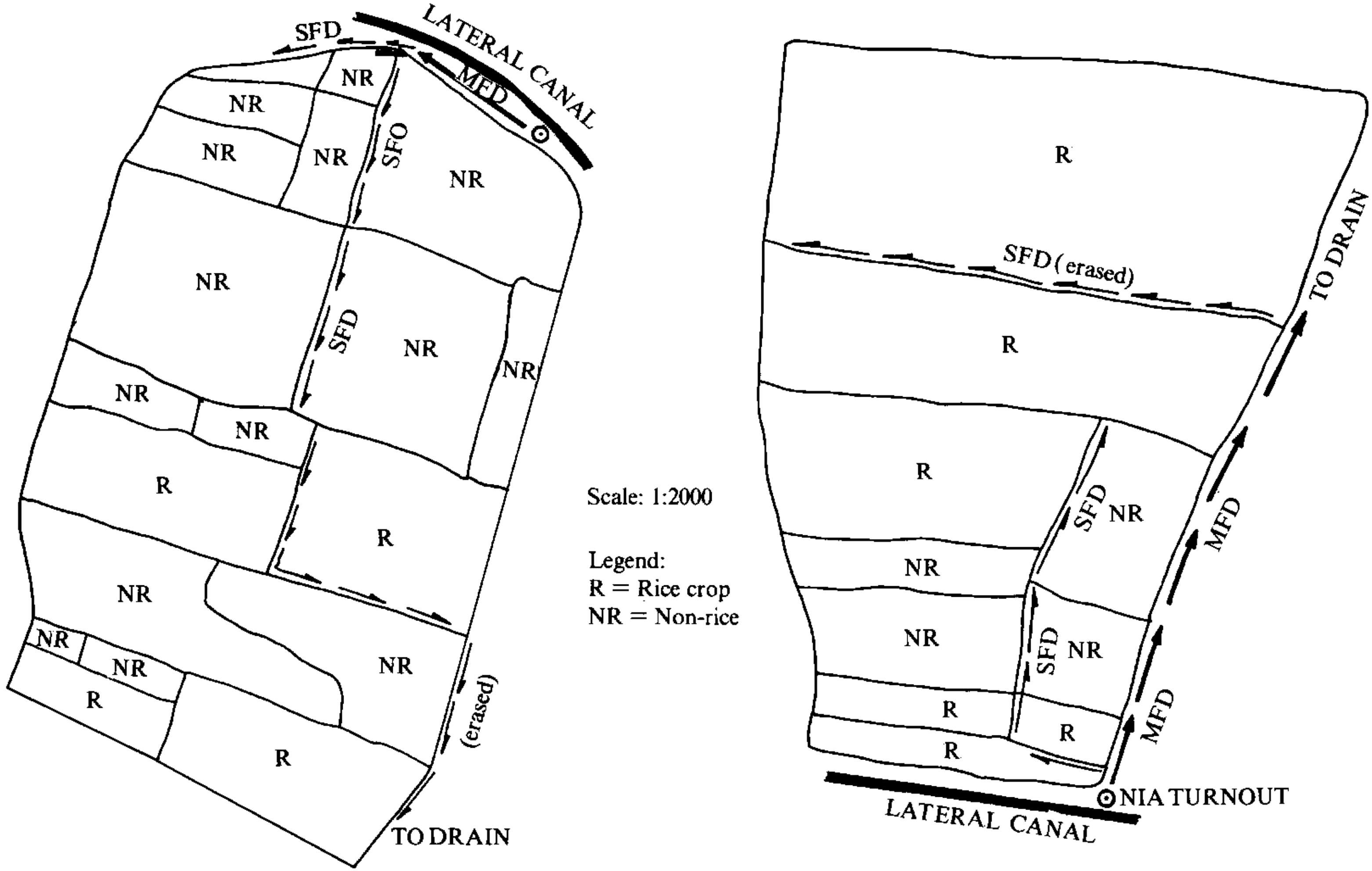
Relaxing SA and SF which are significant variables in Model Ia resulted to a reduced Model IIa. However, the average farm size (FSa) and percent of farms with direct access to farm ditches (PF) significantly affected the lengths of farm ditches. These two physical factors influence the

Table 2. Parameters of five regression models relating farm ditch length (FDL) to physical variables. LVRIS. 1987188 drv season.

Physical Variables	Regression coefficients (T-values in parenthesis)				
	Model la	Model IIa	Model IIIa	Model IVa	Model Va
Intercept	-3184.13	- 3277.10	- 4065 59	-3011.67	- 2025.01
Or	12.80 (0.42)	- 24.69 (0.71)	6.34 (0.21)	7.77 (0.26)	9.86 (0.33)
MFDg	- 4.34 (0.25)	- 13.52 (0.65)	- 1.40 (0.08)	- 2.77 (0.16)	- 3.14 (0.19)
GLs	11.56 (0.67)	26.91 (1.31)	6.98 (0.38)	7.57 (0.41)	10.60 (0.62)
R	30.11 (0.67)	3I.09 (0.57)	38.55 (0.85)	28.24 (0.64)	17.87 (0.41)
NR	31.10 (0.69)	32.10 (0.59)	39.58 (0.88)	29.30 (0.67)	19.06 (0.44)
SA	57.33 (2.78)		140.25 (1.67)	177.60* (2.36)	207.23** (2.88)
FSa	273.50 (1.55)	596.7** (3.36)	186.22 (0.99)		
SF	40.16** (3.23)		27.56 (0.65)	21.57 (0.51)	37.16** (3.02)
PF	0.49 (0.72)	I.64 (2.15)	0.49 (0.72)	0.37 (0.55)	0.34 (0.52)
[SA*SA]			- 28.76 (1.59)	- 34.99* (2.07)	- 31.36* (1.87)
[SF*SF]			- 7.67 (I.23)	- 7.15 (1.15)	
[SA*SF]			27.54 (1.31)	28.49 (1.36)	
R^2	0.55	0.29	0.60	0.59	0.57
F -value	5.09**	2.26**	4.29**	4.59**	5.35**
N	47	47	47	47	47

Note: Or = orientation of main farm ditch (dummy variable); equal to zero when MFD is parallel or equal to one when it is perpendicular; MFDg = main farm ditch gradient (%); GLs = general land slope (%); R = rice farm plot (%); NR = non-rice farm plot (%); SA = size of turnout service area (ha); SF = shape factor (m/m); PF = percent of farms with direct access to farm ditches (%)

* and ** denote significance at 5% and 1% levels, respectively.



a. TSA with MFD 11 to lateral canal

b. TSA with MFD 1 to lateral canal

Figure 1. **Layout of two turnout service areas (TSA's) exemplifying parallel and perpendicular orientations between MFD and supply canal at LVRIS, Ilocos Norte, 1987-88 dry season.**

need, location, and layout of farm ditches as well as the intensity and need of farm level facilities for allocation and distribution of water to farmers sharing a turnout (Tabbal et al., 1983). Farm size determines the number of farmers who will share water delivered through a common turnout. The accessibility of the farm plots to farm ditches reflects the need for additional farm ditches to serve farms which are far from the source. This is consistent with field observations that farmers construct additional farm ditches because of relative need (Svendsen, 1985).

A regression model was developed to show interaction of the significant variables (Table 2, Model IIIa). The interaction [SA*SA] shows the possibility of expanding the service area if farm ditches are adequate. The interactions [SF*SF] and [SA*SF] indicate the relative shape and orientation of the farms to the service area boundaries.

Regression Model IIIa explained 60% of the variations in farm ditch lengths. No single or interaction variables significantly affected the length of farm ditches. However, the model is statistically significant at 1% level.

Relaxing FSa resulted to an alternative Model IVa. The model explained 59% of the variations among samples. The turnout service area (SA) and interactions [SA'SA] significantly affected the length of farm ditches, implying the expansion of the turnout service area, if farm ditches are adequate.

An alternative model which relaxes the interaction variables [SF*SF] and [SA*SA] which were not significant in Model IVa was developed. The alternative model explained 57% of the variation in thelength of farm ditches (Table 2, Model Va). The SA and SF yielded significant effects at 1% level. Moreover, the interaction variable, [SA*SA] was significant only at 5% level.

However, other physical factors, although insignificant in the models, should not be overlooked in the design of terminal facilities (Table 2). The negative coefficient of main farm ditch gradient (MFDg) implies a decrease in the length of farm ditches as the slope increases. Results are consistent with the findings of Levine (1980) that flat areas require longer farm ditches than slopping areas. IRRI-NIA (1984) also found that MFD gradient and land slope greatly influence the flow of irrigation water and thus the duration of water distribution. Murray-Rust et al., (1983) also found that MFDs running perpendicular to the supply canal were easier to maintain than parallel ones.

Optimum Farm Ditch *Density* for ***LVRIS.*** Among the five models developed, the alternative Models IVa and Va were selected to determine the optimum farm ditch density. By taking the derivative of FDL with respect to the significant variable, SA and equating it to zero, the optimum value of SA was obtained. The average values of the non-significant values were then substituted to the equation to determine the optimum farm ditch length. The optimum farm ditch density was obtained by dividing the optimum FDL by the average turnout service area in each orientation category. This procedure was similar to the method used by IRRI-NIA (1984) and David (1974).

Applying the procedure to Model IVa, the optimum FDL obtained was 202 and 210 meters for parallel and perpendicular orientations, respectively (Model IVa, Table 3). Dividing the optimum FDL values by the average SA on each orientation, resulted in the approximate farm ditch density of 110 meter/ha for parallel and 114 meter/ha for perpendicular MFDs, with an average of 112 meter/ha. Optimum density was 4% higher than the mean density of 107 meter/ha.

Using the alternative Model Va, optimum FDL was 268 meter for parallel and 278 meter for perpendicular orientation (Table 3). The optimum farm ditch density was 145 and 151 meter/ha for parallel and perpendicular orientations, respectively, with an average of 148 meter/ha (28% higher than the mean).

Considering cost, labor and time, Model IVa is more appropriate to describe the optimum farm ditch density of LVRIS.

Preliminary results, however, do not imply that the regression models developed were the best regressions. Since best regression is subjective, physical and field observations has to be employed.

Upper *Talavera* River *Irrigation* System ***(UTRIS)***

At UTRIS, 24 TSA's weresurveyed. The sizes of the TSA ranged from 3.4 to 41.2 hectares. Combining the physical factors at each TSA, five regression models were also developed (Table 4). Results of the regression analysis showed that physical factors such as orientation (Or), size of turnout service area (SA), average farm size (FSa), and farms with direct access to farm ditches (PF) significantly affected the total farm ditch length (Table 4, Model Ib). The wider range of values in

Table 3. Optimum farm ditch density, length, and turnout service area, for two different main farm ditch (MFD) orientations, LVRIS, 1987/88 dry season.

	MFD Orientation		Average
	Parallel	Perpendicular	
	MODEL IVa[1]		
Farm ditch density, m/ha	110	114	112
Farm ditch length, m	202	210	206
Turnout service area, ha	1.82	1.85	1.84
	MODEL Va[1]		
Farm ditch density, m/ha	145	151	148
Farm ditch length, m	268	278	273
Turnout service area, ha	1.82	1.85	1.84

[1]Regression Model IVa:

$$FDL = -3011.67 + 7.77\,(Or) - 2.77\,(MFDg) + 7.57\,(GLs) + 28.24\,(R) + 29.30\,(NR) + 177.60\,(SA) - 34.99\,(SA*SA) + 21.57\,SF - 7.15\,(SF*SF) + 28.49\,(SA*SF) + 0.37\,(PF)$$

[1]Regression Model Va:

$$FDL = -2025.01 + 9.86\,(Or) - 3.14\,(MFDg) + 10.60\,(GLs) + 17.87\,(R) + 19.06\,(NR) + 207.23\,(SA) - 31.36\,(SA*SA) + 37.16\,(SF) + 0.34\,(PF)$$

Note: Computed based on average values of MFDg = 0.94%, GLs = 1.58%, R = 25.5%, NR = 74.45%, SF = 11.49, PF = 50.91%.

each unit of observation resulted to a coefficient of determination equal to 87%.

***Optimum** Farm **Ditch** Density for UTRIS.* Among the regression models developed, Model Ib described best the farm ditch density characteristics for UTRIS. Substituting the average physical values at each orientation, the optimum farm ditch density was 117 and 94 meter/ha for parallel and perpendicular orientations, respectively (Table 5).

Combination of Physical Parameters of LVRIS and UTRIS

The combined effect of the physical parameters at each TSA in both sites was tested to determine which variables caused the variation in farm ditch length. The regression model developed explained 80% of the variation of the FDL with respect to the combined factors considered (Table 6). Physical factors such as orientation (Or), size of turnout service area (SA), shape factor (SF) and farm with direct access to farm ditches (PF) appeared to he significant when the average farm size (FSa) was dropped. Notwithstanding the combined effects of the samples from LVRIS and UTRIS, the values of the factors of UTRIS samples biased the model. Thus, it would he misleading to interpret the results of this model without considering physical observations,

Length of farm ditches, average farm size, turnout service area and degree of land utilization under LVRIS and UTRIS differed (Tables 7 and 8). Farm ditches at LVRIS were shorter than at UTRIS. Results were consistent with field observations that some farmers under LVRIS practiced paddy to paddy irrigation and that some supplementary farm ditches were not used to the extent that they were nonexistent.

Field observations at UTRIS showed that the total length of farm ditch oriented parallel to the supply canal were longer than those that were perpendicular (Table 7). Difference in length with respect to orientation was due to factors such as MFD gradient (Model IIb) and general land slope (GLs). At parallel orientation, a shorter MFD was observed due to steeper slopes (MFDg) while a longer SFD was found at flat slopes.

Average farm size and turnout service area were smaller at LVRIS than at UTRIS (Table 8). However, the degree of land utilization at LVRIS was higher than at UTRIS. These differences explain the varying results obtained in the analysis of farm ditch lengths.

Table 4. Parameters of five regression models relating farm ditch length (FDL) to physical variables, UTRIS. 1987/88 drv season.

Physical Variables	Regression coefficients (7-values in parenthesis)				
	Model Ib	Model IIb	Model IIIb	Model IVb	Model Vb
Intercept	-8701.14	- 13945.00	- 6864.44	.3002.91	- 3621.35
Or	-1086.16'.	-637.96	-1021.16	-1050.23*	-1045.64
	(2.50)	(0.79)	(2.20)	(2.19)	(2.04)
MFDg	1455.02	3374.13*	986.29	779.64	1036.47
	(1.85)	(2.48)	(1.02)	(0.79)	(1.11)
GLs	687.91	-504.80	464.94	157.10	581.82
	(1.09)	(0.47)	(0.60)	(0.21)	(0.77)
R	41.27	102.88	34.79	16.28	8.48
	(1.84)	(2.03)	(1.17)	(0.60)	(0.29)
NR	53.33	110.07*	46.80	28.42	19.77
	(1.84)	(2.13)	(1.58)	(1.05)	(0.68)
SA	133.06**		105.30	84.15	97.42
	(6.27)		(0.99)	(0.77)	(0.93)
FSa	863.45**	1524.03*	613.22		
	(2.30)	(2.26)	(1.34)		
SF	-15.61		-30.30	-135.42	-27.28
	(0.35)		(0.17)	(0.84)	(0.52)
PF	41.89**	44.19*	31.87*	23.24	35.55*
	(4.02)	(2.50)	(2.40)	(1.94)	(2.97)
[SA*SA]			2.43	3.69	0.60
			(0.94)	(1.49)	(0.27)
{SF*SF]			14.02	21.61*	
			(1.31)	(2.30)	
[SA*SF]			-12.82	-16.35	
			(1.56)	(2.04)	
R^2	0.87	0.50	0.90	0.88	0.83
F-value	11.12**	2.36**	8.28**	8.32**	7.69**
N	24	24	24	24	24

Note: Or = orientation of main farm ditch (dummy variable); equal to zero when MFD is parallel or equal to one when it is perpendicular; MFDg = main farm ditch gradient (%); GLs = general land slope (%); R = rice farm plot (%); NR = non-rice farm plot (%); SA = size of turnout service area (ha): SF = shape factor (m/m); PF = percent of farms with direct access to farm ditches (%)

* and ** denote significance at 50, and 1% levels, respectively.

Table 5. Optimum farm ditch density', length, and turnout service area. for two different main farm ditch (MFD) orientations, UTRIS, 1987/88 dry season.

	MFD Orientation		
	Parallel	Perpendicular	Average
Farm ditch density, m/ha	117	94	104
Farm ditch length, m	2013	1848	1924
Turnout service area, ha	17.20	19.60	18.50

'Regression Model Ib:

$$FDL = -8701.14 - 1086\,(Or) - 1455.02\,(MFDg) + 678.91\,(GLs) - 41.72\,(R) + 53.33\,(NR) + 113.06\,(SA) + 863.45\,(FSa) - 15.61\,(SF) + 41.89\,(PF)$$

Note: Computed based on the average values in each orientation.

Table 6. Coefficient of regression[a] relating farm ditch length (FDL) to combined physical variables of LVRIS and UTRIS, 1987/88 dry season.

Physical Variables	Regression Coefficient	Std Error Of Est.	T-value
Intercept	-717.09		
Orientation of MFD[b] (Or)	-405.83*	1699.78	2.36
MFD gradient (MFDg)	-13.34	171.71	0.11
General land slope (Gls)	43.63	120.51	0.36
Percent of farms planted to rice (R)	-1.55	16.86	0.09
Percent of farms planted to non-rice (NR)	4.15	16.86	0.24
Average farm size (SA)	132.23**	35.46	3.73
[SA*SA]	0.07	0.86	0.08
Shape factor (SF)	-74.83**	26.83	2.70
Percent of farms with direct access to FD (FF)	12.50**	3.77	3.31

Coefficient of determination, R^2 = 0.80
F-value = 26.96**
N = 71

[a]Regression model:

FDL = -717.09 -405.83 (Or) -13.34 (MFDg) + 43.63 (GLs) -1.55 (R) + 4.15 (NR) + 132.23 (SA) + 0.07[SA*SA] -74.83 (SF) + 12.50 (PF)

[b]Dummy variable: 1 if the MFD is perpendicular lo supply canal and 0 if it is parallel.

**Significant at 1% level
*Significant at 5% level

Table 7. Mean main (MFD) and supplementary SFD farm ditch lengths in meters for two different orientations of **main** farm ditches, LVRIS and UTRIS, 1987/88 drv season.

Location	Orientation	Farm Ditch Length MFD	SFD	Average
LVRIS	Parallel	144	38	196
	Perpendicular	125	48	197
Average		135	43	196
UTRIS	Parallel	499	1514	2013
	Perpendicular	750	1099	1848
Average		635	1289	1924

Table 8. Average farm size in hectares by main farm ditch (MFD) orientation, LVRIS and UTRIS, 1987/88 dry season.

Location	MFD Orientation Parallel	Perpendicular	Average
LVRIS	0.31	0.32	0.31
UTRIS	1.44	I.27	1.35

Results of the combined model in conjunction with field observations indicate that two sets of values must be considered in designing systems for mixed cropping during the dry season. For areas where the average farm size is less than 0.50 hectare, the optimum turnout service area should be less than 3 hectares. For areas with average farm size of less than 2 hectares but larger than I hectare, the turnout service area should be less than 20 hectares. Furthermore, regardless of the differences in sizes of areas, the farm ditch density for both cases will have to be 100 meter/ha, on the average.

Conclusion and Recommendation

On-farm ditches are indispensable in water distribution. Adequate farm ditches facilitate equitable water distribution.

Lengths of farm ditches are generally affected by physical factors such as size of turnout service area, orientation of main farm ditch, shape factor, farm with direct access to farm ditches, main farm ditch gradient and land slope. Preliminary results showed that the regression models signify dependence of farm ditch density on the explanatory variables.

The regression models developed illustrated the effects of the factors considered based on actual conditions under LVRIS and UTRIS. However, the equations could not be used to predict the needed farm ditch by substituting values obtained from a certain area.

Factors like land slope, shape and orientation entail costly modifications to conform with an optimum value.

Each area has its own peculiarities and in most cases it is desirable to establish farm ditches at proper boundaries.

Compared to the optimum farm ditch density found by the IRRI-NIA study for rice areas (1984), the values obtained for the study sites were much higher, indicating a higher farm ditch density for diversified crops areas. Optimum turnout service areas for the study sites were also less than the value obtained by IRRI-NIA.

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On-farm Irrigation Method at the Laoag Vintar River Irrigation System

Carlos M. Pascual [1]

Abstract

Basin flooding is the usual method **of** irrigating mulched garlic during the dry season under the Laoag Vintar River Irrigation System. Field observations showed that the flow rate under basin flooding ranged from 10-33 liter per second (lps), with a weighted average of 21 Ips. Duration of irrigation ranged from 10-26 **hr/** ha, with a weighted average of 14 hr/ ha. Irrigation interval ranged from two to three weeks. Advance and recession profiles showed distinct ***high*** and ***low*** spots in the basin plots. Yield response curve showed a threshold value of **300** mm of water applied. Application efficiencies ranged from **57-73%,** with a weighted average of ***65%.*** Regression analysis of application efficiency and stream size showed an optimum critical flow rate of 25 Ips to attain a potential efficiency of **76%.**

Introduction

Every irrigation method has advantages and disadvantages. An irrigation method is best when it is suited to local conditions. An irrigation method should be flexible in order to apply varying depths of water to meet the needs of different crops or of the same crop at different stages of growth.

Irrigation methods vary depending on the availability of water, soil type, climate and cultural practices employed hy farmers. They also vary depending on location, due to differences in local conditions such as crops grown, topography and water quality (Johl, **1970).**

Improved management of water at the farm level conserves water, labor and soil and also increases crop yield. Evaluating an irrigation method is a must to determine its effectiveness (Merriam and Keller, 1979). Results of the evaluation will also provide management with the needed information whether to modify a method or not.

Objectives

The study aimed to develop an irrigation method suited for garlic. Specifically it aimed to: (I) document and evaluate existing on-farm irrigation practices for garlic during the dry season; and (2) recommend improvement/ modification of the existing irrigation method.

Site, Duration and Limitation

The study was conducted at the Laoag-Vintar River Irrigation System (LVRIS), one of the eight irrigation systems under the Ilocos Norte Irrigation Systems (INIS) located in the province of Ilocos Norte. LVRIS is a gravity-type irrigation system serving **2377** hectares (Figure **1**). Irrigation practices for garlic were observed during the 1987/88 dry season at farm plots owned by selected farmer-cooperators that were located along the areas served by laterals B (Vintar town), F (Barangay Dibua) and H (Barangay San Mateo), and by sub-laterals Flc (Barangay Sta Maria) and Fld (Barangay Navotas).

Methodology

Five sites, planted mostly to garlic, were selected. Sample paddy fields representative of each site were considered as the units of observation. To estimate stream **size,** duration and interval between irrigation, advance and recession of irriga-

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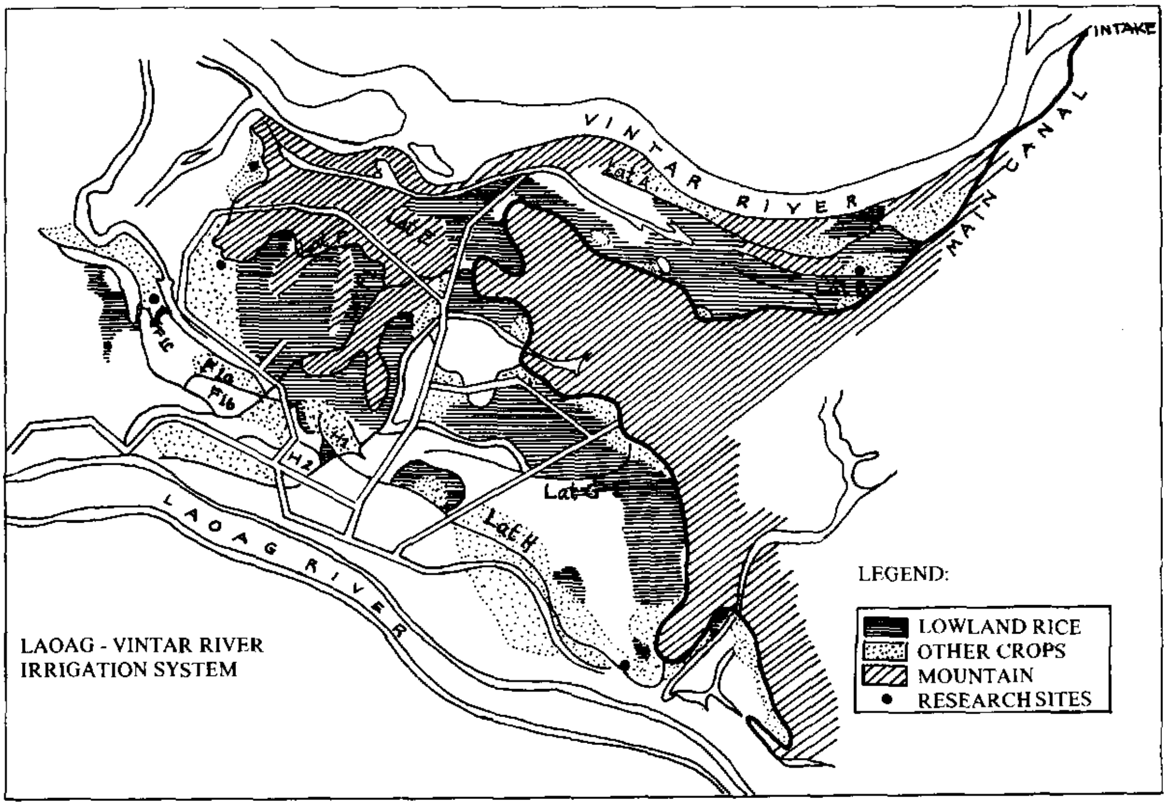


Figure 1. Map of the Laoag-Vintar River Irrigaton System (LVRIS), Ilocos None, Philippines showing cropped areas and research sites during the 1987-88 dry season.

tion water, and application efficiency, data were collected from the selected farm plots using participant observation technique and standard irrigation evaluation procedure. Farmers' management and cultural practices were also monitored.

Stream Size Measurement

To measure the stream size conveyed to the farm plots, 5-cm by 60° trapezoidal, 30-cm cutthroat and 7.5-cm Parshall flumes were installed at the inlet of the head ditch of each selected farm plot. Duration and interval between irrigation, as well as irrigated area were also determined.

Application Efficiency

Application efficiency was measured in the traditionally-farmed garlic farms as an index of an irrigation method's efficiency.

Amount of water applied to each field was measured from the flumes installed at the inlet of the head ditch. To determine water stored in and depleted from the root zone, soil samples were collected from the effective root zone up to 45 cm deep at 15-cm interval. Samples were taken two to three days after irrigation with soil moisture content assumed at field capacity and one day before the next irrigation with the difference as the amount depleted. Soil moisture content. was determined by oven drying. Bulk densities at various depths in each farm plot were also determined using core sampler.

Advance and Recession of Irrigation Water

Grid stakes at equal intervals were laid within selected farm plots. The advance of the water stream across the basin was observed by recording the time when water reached any stake. The receding water front at several stakes after the inlet supply of irrigation water has been shut off was also noted.

Rainfall, Evaporation, Crop Yield and Management Practices

Class A pan and standard non-recording rain gauge were installed to measure rainfall and evaporation, respectively. From a 2×2 meter area taken at random from each farm plot, crop cuts were collected one day before harvest. Harvested garlic were cleaned, weighed and sun-dried for about three weeks. Crop cut yields were expressed in t/ha. Planting, tillage operation, fertilizer application, occurrence of pest and diseases and other cultural practices were also observed.

Results and Discussion

Laoag Vintar River Irrigation System *(LVRIS)*

LVRIS belongs to rainfall Type I; with two pronounced seasons, i.e. dry from November to April and wet during the rest of the year. During the dry season, diversified crops subsisted on irrigation due to zero rainfall (Figure 2). Average weekly evaporation during the dry season was 32 mm/day. Because of fragmented and small landholdings (less than 0.5 hectare), most farmers planted and irrigated diversified crops such as garlic, tomato, mungbean (planted after garlic), watermelon and other vegetables during the dry season. Results of the on-farm level survey showed that 95% (60 sample farmers) of the respondents preferred to plant rice, if there was sufficient water supply during the dry season (Table 1). This implies that availability of water for irrigating rice is an important factor to consider in irrigated diversified cropping. However, only 52% of the farmers were satisfied with the dry season water deliveries. Almost all farmers interviewed wanted to improve their existing irrigation practices.

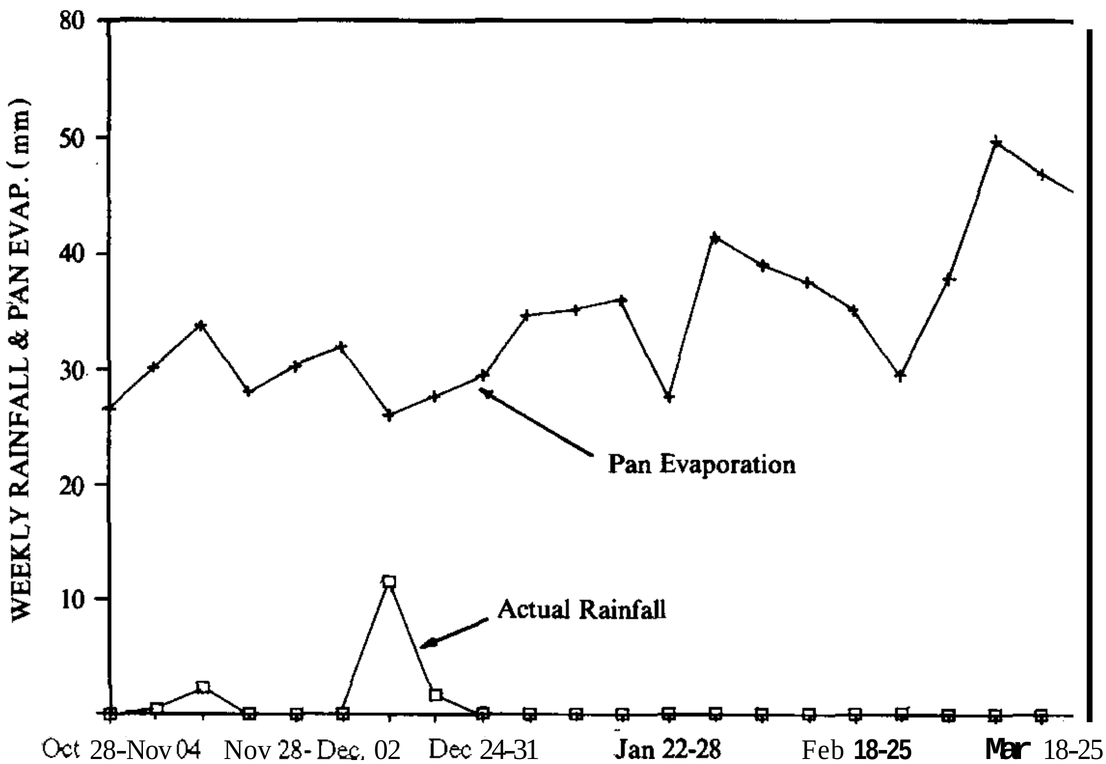


Figure 2. Weekly rainfall and pan evaporation at Laoag-Vintar River Irrigation System, Ilocos Norte, Philippines, 1987-88 dry season.

Table 1. Proportion of fanners relating some irrigation management perception with dry season water supply by location. LVRIS, 1987/88 dry season.

	Sections							
	Head (n=20)		Middle (n=20)		Tail (n=20)		Total (n=60)	
	No.	%	No.	%	No.	%	No.	%
Willing to plant rice if sufficient water is available	17	85	20	100	20	100	57	95
Satisfied with the dry season water supply	16	80	8	40	7	35	31	52
Willing to improve irrigation practices	20	100	20	100	20	100	60	100

Cultural Management Practices for Garlic

Garlic is the most profitable dry Season crop planted after rice in northern Luzon. In 1988, price of garlic increased from 725 to ₱180/kg. Under LVRIS, land preparation did not always entail tillage operation. In tilled farms, most farmers used carabaodrawn implements for plowing and harrowing operations. Others hired a tractor to harrow the field for two to three passing at ₱0.12/m^2. Field plots in San Mateo were harrowed twice. In untilled farms where the previous crop was rice, straw and weeds were cut close to the ground. The field was drained to field capacity and covered with rice straw before planting the seeds. Rice straw about 5 cm thick were spread over the farm plots as mulch.

Most farmers used pointed bamboo sticks to dibble the soil and to plant the garlic seed cloves. The seed cloves were then inserted vertically into the soil to about 2-3 cm deep. Planting distance ranged from 20×20 cm to 25×25 cm. Occurrence of root rot and leaf spot at vegetative stage and tangle top at bulbing until maturity were observed. Occurrence of these diseases was attributed to soil moisture and humid environment during the day. It was observed that growth of broad-leafed weeds was minimal on mulched garlic, however, mulching was not effective in controlling g-asses and sedges. Manual weeding was done by using family and/or hired labor. Most farmers appliedureaand complete fertilizers either by broadcast or dibbling methods. Fungicide was also applied.

Existing On-Farm Irrigation Management Practices for Garlic

Method and Scheduling of Irrigation. Under LVRIS, basin flooding was the usual method of irrigating mulched garlic (Ilocos White variety) during the dry season. Irrigation water was conveyed from the supplementary and/or internal farm ditches to the side of the basin. The basin was flooded and water was allowed to infiltrate the soil. Most of the moisture was retained in the basin.

Garlic is usually irrigated three to four times, depending on the availability of water and rainfall (Table 2). A heavy pre-planting irrigation was usually done to soften the tillage pan to ease planting. Pre-planting irrigation was done three to four days before planting when the rice straw mulch was laid on the soil surface. Irrigation was also applied at pre-bulbing and bulbing stages to facilitate the removal of weeds and fertilizer application. Light irrigation at maturity was applied to soften the soil to ease harvesting operation and to facilitate land preparation for the next crop, usually mungbean. Depth of irrigation water applied ranged from 8 to 11 cm, with a weighted average of 10 cm. Most basins bad enclosed dikes to prevent runoff. Some dikes, however were farmed, built up and were easy to break. This means that non-rectangular basins matching soil boundaries are feasible (Memam and Keller, 1979).

Table 2. Irrigation scheduling and depth of water applied during the various growth stages of garlic, LVRIS, 1987/88 dry season.

Order of Irrigation	Growth Stage	Days After Planting (days)	Depth of Water Applied (cm)
First	(Pre-planting)'		10
Second	Pre-bulbing	30- 40	10
Third	Bulbing	50- 80	11
Fourth	Maturity	90-120	8
Weighted Ave			10

*Pre-planting irrigation is done three to four days before planting when rice straw mulch are spread over the fields.

Flow Rate, Duration and Interval Between Irrigation

Field observations revealed that the flow rate used for garlic irrigation ranged from 10-33 Ips, with an average of 21 Ips (Table 3). Field observation also showed ihat erosion at these flow rates was minimal. Rice straw mulch served as buffer against erosion, especially for high flow rates. Field plot sizes ranged from 0.07-0.2 hectare. Duration of irrigation application ranged from 0.7-2.2 hour. Irrigation intervals were from two to three weeks depending on the availability of water and rainfall.

It was observed that some farmers applied water considering the flow rates but not the rooting depth and advances of uniform stream in their fields. Farmers had little knowledge about the two basic criteria questions in irrigation - "when to irrigate?" and "how much water to apply?? Limited water supply and unequal rotational distribution during dry season coupled with low density of farm ditches to convey irrigation water to the farthest point of the turnout resulted in farms located at the tail section receiving inadequate irrigation water.

Yield of Garlic. Estimate from crop-cut samples showed varying mean yield (Table 3). Farms in Vintar obtained the highest yield at 2.28 t/ha, followed by farms in San Mateo, 2.21 t/ha. Lesser yields were observed in farms located at the tail section because of the occurrence of root rot and tangle top, and sediment-transport when the fields were flooded during the August 1987 typhoon.

Based on the yield response curve, threshold value of water applied was 300 mm (Figure 3). Availability of water was not associated with higher yields. Results are consistent with the nature

Table 3. Mean yield, water use, flow rate and duration of irrigation for garlic, LVRIS, 1987/88 dry season.

Site	Mean Yield (t/ha)	Water Applied (mm)	Flow Rate (lps)	Duration (hr/ha)
Vintar	2.28	576	33	12
San Mateo	2.21	298	14	17
Dibua	1.72	405	17	11
Navotas	1.62	246	22	10
Sta. Maria	1.75	299	10	26
Weighted Ave	1.93	406	21	14

of the crop since garlic requires less water and is very sensitive to wet conditions.

Advance and Recession ***Profiles.*** Advance and recession profiles indicate abnormal change from uniform normal condition of the irrigation method.

Advance and recession isotime profiles show distinct high and low spots in some fields (Figure **4).** These spots cause differences in water infiltration resulting to non-uniform distribution and low application efficiency. To minimize these problems, levelling is recommended for basin method; or a possibility of border or small corrugations to speed up irrigation, can also improve the current irrigation practice. However, these alternatives require additional cost, labor, and- have some adverse effects on farm sue; although in some countries like Taiwan and Thailand border irrigation in garlic has been found effective.

Application Efficiency. Application efficiency is a measure of uniformity but it does not indicate the adequacy of irrigation. Stream size, depth of water over the soil surface, and infiltration rate influence application efficiency (Hansen et al.. **1979).** Application efficiency estimates were generally low and extremely variable (Table **4).**

An efficiency of **73%** was observed in farms in Navotas and San Mateo. Mean application efficiency of the system was ***65%.*** The relatively higher efficiency observed compared with other sites was due to lesser amount of water applied. High efficiency also shows that water allocation and distribution depend on the farm's location within the system.

Computed application efficiencies of basin-flooding irrigation for garlic indicated that all cases had an efficiency of less than **90%** and the highest frequency was in the range of 80-90% (Table ***5).***

Figure **5** shows the relationship of application efficiency with stream size. The second degree curve shows that the optimum streamflow rate was 24 lps. Using this flow rate, the estimated optimum application efficiency of **76%** was within the desirable range of about **60-85% for basin** irrigation method (Merriam and Keller, **1979).**

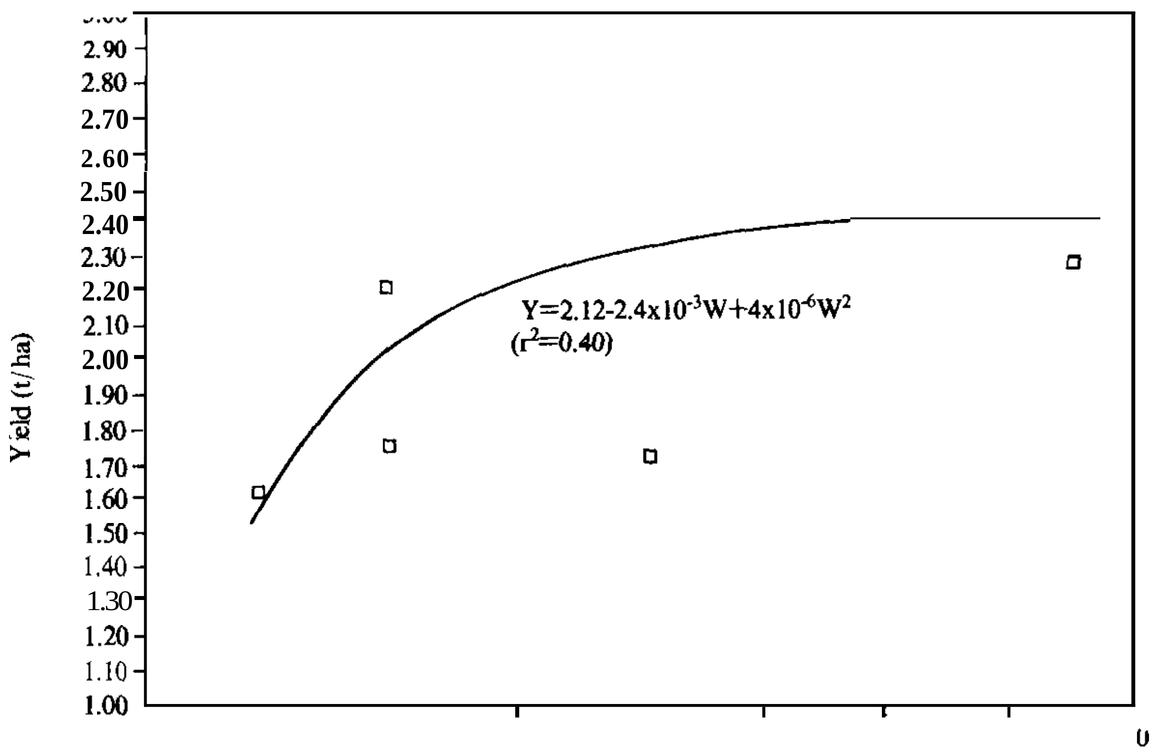
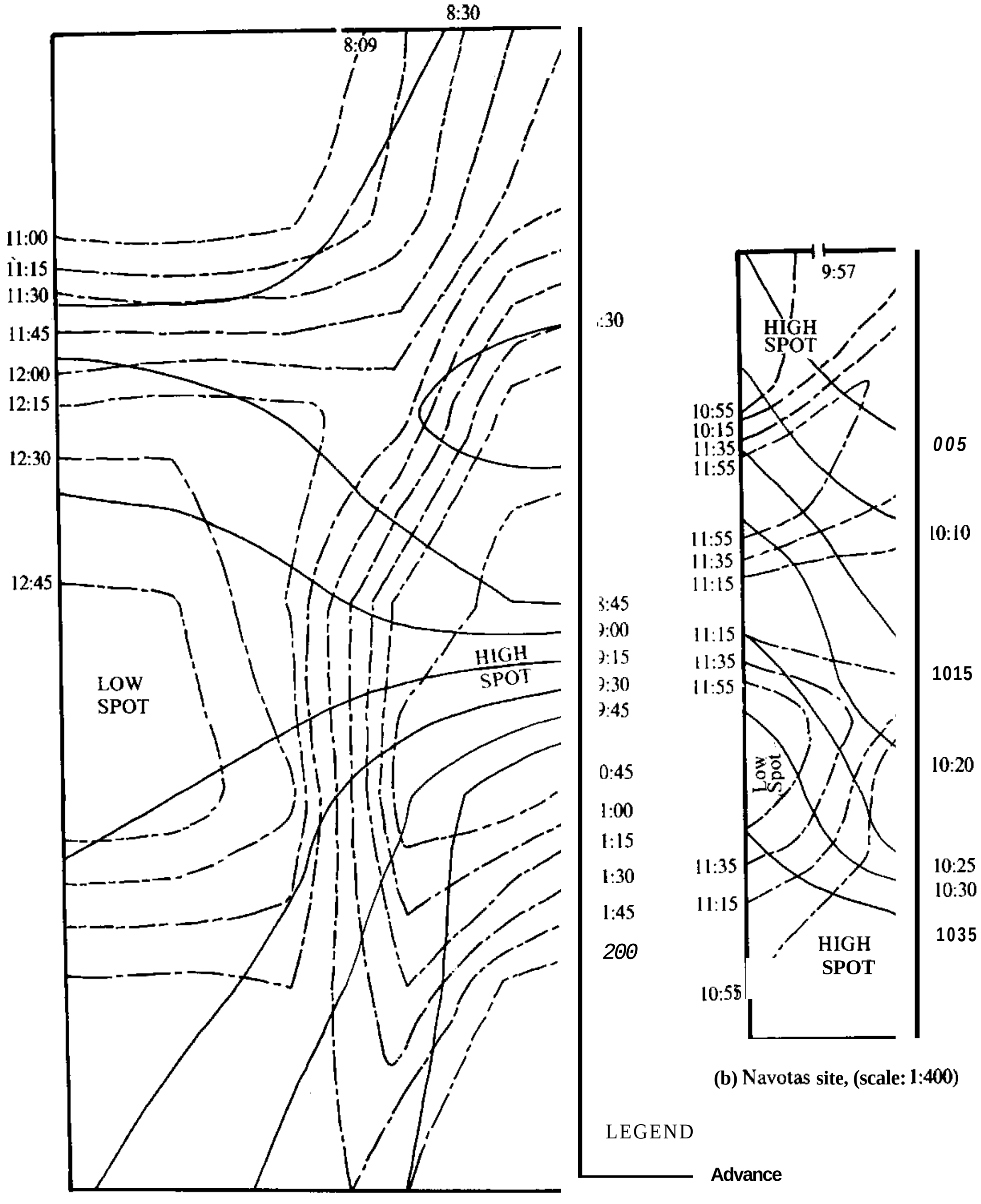


Figure 3. Yield response of garlic to the total water applied at farmers' field, Laoag-Vintar River Irrigation System, Ilocos Norte, Philippines, **1987-88** dry season.



(a) Vintar site, (scale: 1:300)

(b) Navotas site, (scale: 1:400)

Figure 4. Isotime profiles of **flowing** stream of basin-flooding irrigation on mulched garlic at farmers' field, **LVRIS,** Ilocos Norte, 1987-88 dry season.

Table 4. Soil type, total water applied, stored and application efficiency of basin irrigation of garlic, LVRIS, 1987/88 dry season.

Site	Soil Type	Total Supplied (mm)	Total Stored (mm)	Application Efficiency (%)
Vintar	Clay loam	576	399	69
San Mateo	Loam	298	217	73
Dibua	Loam	405	242	59
Navotas	Sandy loam	246	217	73
Sta. Maria	Sandy loam	299	I70	57
Average		406	270	65

Table 5. Variation of application efficiency of basin irrigation of garlic, LVRIS.

Application Efficiency Interval	No. of Observation	% of Total Observation	Accumulated (%)
0 - 10			
10 - 20			
20 - 30	1	5	5
30 - 40	2	11	16
40 - 50	1	5	21
50 - 60	2	11	32
60 - 70	4	21	53
70 - 80	4	21	74
80 - 90	5	26	100
90 - 100			
Total	19		

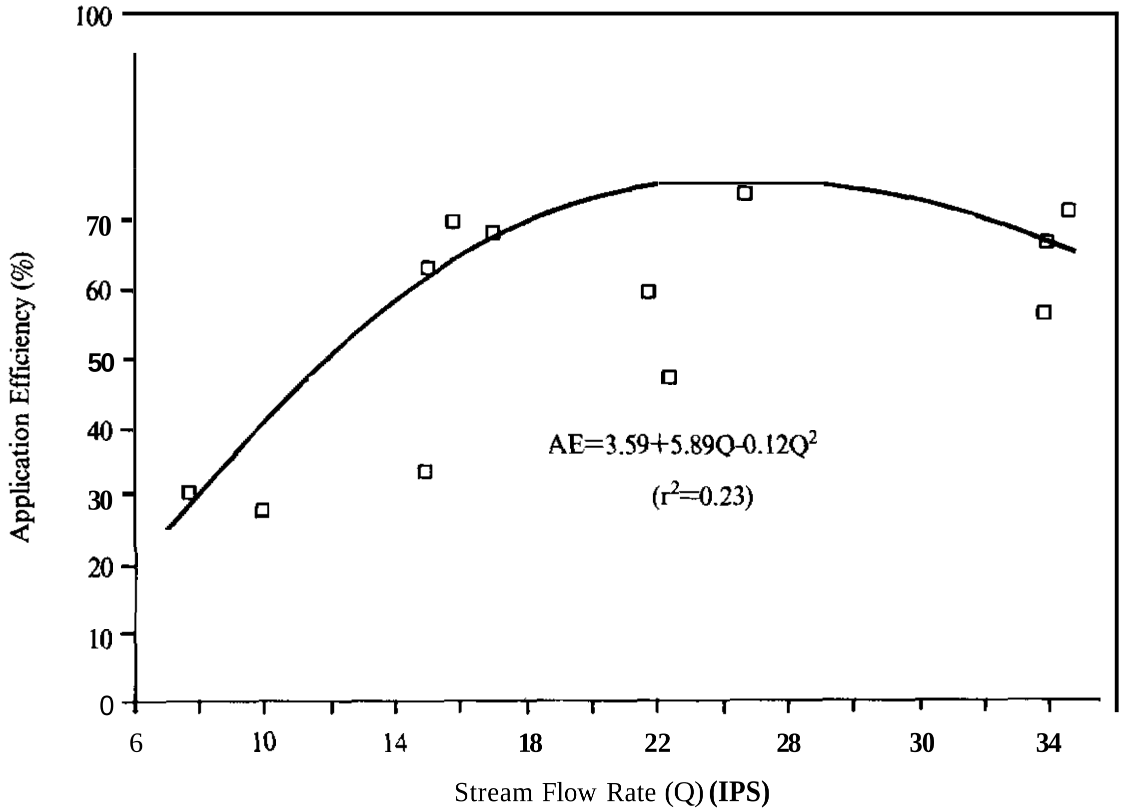


Figure 5. Relationship between application efficiency and stream size on basin-flooding of garlic at farmers' field, Laoag-Vintar River Irrigation System, Ilocos Norte, Philippines, **1987-88** dry season.

Conclusion and Recommendation

Farmers have been traditionally planting garlic **as** a diversified crop during the dry season. Basin-flooding was the method used to irrigate garlic.

Basin-flooding irrigation method can be efficient only when the basin **is** carefully graded and leveled, intake rate of the soil **is** uniform and the correct depth of water is applied in due time considering the time of ponding of irrigation water.

The existing irrigation method can be modified using either a "contour-like" basin without removing the cross slope, or by constructing down slopes like border-strips.

Thorough evaluation of the irrigation method at farmers' field is recommended to develop an innovative irrigation technique that will maximize land, water, soil and labor use.

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Comparative Economic Analysis of Diversified Crops Under Irrigated and Rainfed Conditions and their Irrigated Performance versus Irrigated Rice

Margarita P. Caluya and Charito G. Acosta [1]

Abstract

A comparison of the profitability of selected diversified crops under irrigated and rainfed conditions and their irrigated performance with that of irrigated rice under the Laoag Vintar River Irrigation System (LVRIS) and Bonga Pump No. 2 (BP#2) was done during the dry cropping seasons 1986-88.

Predominant cropping patterns identified were rice-garlic-mungbean and rice-rice-mungbean.

The study found that:

- Under LVRIS. material costs for irrigated garlic was higher than irrigated rice during the 1986/87 dry season. During the 1987/88 dry season, gross returns, total family labor, materialcosts, total variable costs, and returns above variable cost for irrigated garlic were higher than for irrigated rice. Under BP#2, results were almost similar during both cropping seasons.
- Under LVRIS and BP#2, no significant differences were observed between the economic parameters of irrigated rice and irrigated mungbean during the 1986/87 dry season. During the 1987/88 dry season, however, gross returns, labor and power costs, material costs, totalvariablecosts. and returns lo material costs were higher for irrigated rice than for irrigated munghean.
- Material costs and total variable costs were higher for irrigated garlic than irrigated rice under both systems during the 1986/87 dry season. During the 1987/88 cropping at LVRIS and BP#2, gross returns, total family labor, labor and power costs. material costs, total variable costs, and returns above variable costs was higher, while returns to material costs was lower for irrigated garlic than for irrigated mungbean.

A follow-up survey is recommended for more conclusive results.

Introduction/Significance

llocano farmers have been traditionally planting diversified crops in irrigated areas. However, the socio-economicviability of this practice is still vague. Thus, data on production (e.g. resource use, cropping systems, farm inputs and yield) and economic iactors (e.g. prices, marketing practices and systems, credit, etc.) must be gathered, analyzed and documented. Data gathered will serve as baseline information in determining farm profitability and will also serve as a tool in guiding farmers in decision-making for agricultural production. Government agencies can also refer to this study in formulating policies relevant to irrigation systems and management.

Objectives

The study aimed to compare the profitability of selected diversified crops under irrigated and rainfed conditions, and their performance with irrigated rice. Specifically, the study aimed to: (a) identify existing cropping patterns and compare their profitability; (b) identify the most efficient means of utilizing family labor; *(c)* determine the net returns to family labor and investment; and (d) identify the economic factors affecting crop diversification.

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Methodology

Two hundred seventy three farmers under the Laoag Vintar River Irrigation System (LVRIS) and Bonga Pump No. 2 (BP#2), 49 farmers with rainfed crops, and 14 wholesalers/retailers operating in theareawere interviewed during the 1986/87 dry season.

Sample size was predetermined during the 1987/88 dry season survey. The questionnaire used was similar to the one used during the 1986/87 survey except for the section on traders which was disregarded in the later survey. The survey covered (a) 120 farmers practicing Rice-Garlic-Mungbean cropping pattern (R-G-M CP) and 40 farmers practicing Rice-Rice-Mungbean cropping pattern (R-R-M CP) under LVRIS; (b) 40 farmers practicing R-G-M CP and 40 farmers practicing R-R-M CP under BP#2; and (c) 40 farmers planting rainfed mungbean crop.

Demographic and socio-economic characteristics, capital assets, cropping patterns, credit and marketing systems weredetermined andcompared. Economic parameters were compared separately among crops (e.g. irrigated rice and irrigated garlic, irrigated mungbean and rainfed mungbean, etc.) and among the three irrigation systems using t-test.

Results and Discussion

Most farmer-respondents in irrigated areas were 45-57 years old. In rainfed areas, majority of the farmers' ages ranged between 50-62 years. Wives on the other hand, were 45-57 years old and 24-36 years old in irrigated and rainfed areas, respectively. Majority of the children and relatives' ages were from 1-21 years old in both areas (Table 1).

Table 1. Demographic characteristics of farm households, 1986/87 and 1987/88 dry seasons.

Characteristics	Irrigated			Rainfed		
	Range; Bracket	(%)	[No.)	Range; Bracket	(%)	(No.)
Age Structure						
Farmers	45-57	40	513	50-62	37	49
Wives	45-57	35	449	24-36	37	43
Children/relatives	1-21	71	1928	1-21	73	183
Educational Attainment[b]						
Farmers	01-06	48	513	01-06	71	49
Wives	01-06	72	449	01-06	46	43
Children/relatives	01-06	38	1928	01-06	35	183
	11-15	26	1928	00	24	183
Household Size	4- 6	50	513	4- 6	55	49
	7-10	27	513	7-10	24	49
No. of Years in Farming	28-40	29	513	41-53	24	49
	15-27	25	513	48-40	34	49
Annual rice requirement[a]						
Minimum, cavans	12-20	58.6	273	12-20	53.1	49
Maximum, cavans	15-25	56.0	273	15-25	49.0	49

"data for 1986/87.

[b] 00 no formal schooling/pre-schooling
01-06 Grade I to Grade VI
07-10 First year to Fourth year high school
11-15 First year to fifth year college

Most of the farmers and their wives, children and relatives finished elementary grade school, although considerable number reached or even finished high school.

Average household size in both areas ranged from 4-6 members. Minimum annual rice requirement per family ranged from 600-1000 kg while maximum rice requirement per family ranged from 750-1250 kg.

Farmers in rainfed areas had longer farming experience (28-53 years) than farmers in irrigated areas (1540 years).

Choice of crop planted and farm size. Farmers considered some factors in choosing the kind of crop to plant during the dry season. Availability of water ranked first, especially among farmers whose farms were located at the tail end of the lateral. Next in rank were availability of market, credit, seeds/planting materials and the perceived high returns from the crops as well as risks involved. Experience in the previous dry season was also considered.

Farm size planted to a particular crop was also determined on the following in the order of importance: amount of available water, market demand for the crop, and experience during the previous dry season. Risk involved, availability of labor, credit and planting materials were least considered.

Table 2. Inventory of tools, equipment and infrastructure of farmers in irrigated and rainfed areas, 1986/88 cropping seasons.

Farm Buildings, Equipment and Tools	Irrigated Owner	N=5 I3 Percent	Rainfed Owner	N=49[a] Percent
Bodega	213	42	20	41
Carabao/cow shed	297	58	38	78
Sled (1-2)	318	62	21	43
Cart (1-2)	290	56	43	88
Sprayer (1-2)	212	53	35	71
Drying materials (1-5)	426	83	39	80
Spade (1-2)	410	80	39	80
Hoe (1-2)	221	43	15	31
Bolo (1-2)	513	100	49	100
Scythe (I-10)	513	100	49	100
Sacks (1-300)	513	100	49	100
Carabao (1-4)	293	57	9	18
Cow (1-4)	269	52	42	86
Plow (1-4)	490	96	47	96
Harrow (1-3)	456	89	41	84
Rolling hoard	56	11	5	10
Plaining board	241	47	16	33
Tractor tiller	19	4	0	0
Irrigation pump	61	12	34	69
Thresher/samberga	226	44	19	39
Others (basket, hose, "karadikad")	226	52	3	6

[a]1986/87 data.

Family contribution to various farm activities. Farm activities were shared between family members. Wives, children and other relatives contributed mostly in planting, weeding, harvesting and threshing operations. However, farmers themselves took the lead role in all farm activities.

Farm inventory. An inventory of farm tools, equipment and buildings was made. All farmer-respondents had most of the basic tools like bolos, scythes, plows, harrows, spades and draft animals. Only a few owned equipment which involved high capital investments (Table 2).

Production problems. Table 3 shows the production problems encountered by farmers. Under LVRIS, occurrence of pest and diseases was the foremost problem while farms located at the middle and tail sections of the laterals were beset with inadequate water supply. Charging high irrigation fees was a problem to farmers under

BP#2. Other problems considered were high cost of chemicals, lack of capital, high cost of land rent or sharing percentage, and high cost of seeds.

Cropping patterns (CP). During the 1986/87 survey, various cropping patterns were identified. Farmers planted as many as five different crops during the dry season (November to May). Predominant cropping patterns identified were Rice-Garlic-Mungbean and Rice-Rice-Mungbean. These cropping patterns were the bases of selecting farmer-respondents for the 1987/88 survey, especially for garlic and mungbean.

Comparison of irrigated rice with selected diversified crops. A summary of yield, gross returns, total cost of production and net returns of rice and two selected diversified crops under LVRIS and BP#2 during the 1986/87 and 1987/88 dry seasons is presented in Table 4

- Irrigated rice versus irrigated garlic
  - — LVRIS. During the 1986/87 dry season, material cost for irrigated garlic was higher than for irrigated rice. During the 1987/88 dry season, total family labor, gross returns, material cost, total variable cost and consequently, the returns above variable cost were higher for irrigated garlic than irrigated rice. Total variable cost for irrigated garlic was higher due to an increase in material cost on account of material needed for mulching (Table 5).

Table 3. Production problems encountered by farmers during the 1986/88 dry seasons

Problems	Rank			
	LVRIS			BP#2
	Head	Middle	Tail	
Inadequacy of water supply	2	1	1	
High cost of chemicals	2	2	3	2
Attack of pest and diseases	1	1	2	2
Lack of capital	3	3	3	
Lack of seeds		2	2	
High interest rate on borrowed capital		1	2	
High irrigation fees				1
Delayed releases of loans		3		
High cost of land rent or sharing percentagr	3	3	3	3
High cost of seeds		3	3	

Table 4. Yield, cost and returns of selected diversified crops under LVRIS and BP#2, 1986/87 and 1987/88 dry seasons.

Crops	Cropping Season	Sites	Yield (kg/ha)	Gross Returns (₱/ha)	cost of Production (₱/ha)	Net Keturn (₱/ha)
Rice	1986/87	LVRIS	5013	12804	5915	6890
	1987/88		3034	10628	4821	5807
	1986/87	BP#2	3367	10486	4849	5630
	1987/88		4159	14558	8992	5656
Garlic	1986/87	LVRIS	1700	17711	9588	8123
	1987/88		754	25596	11590	14006
	1986187	BP#2	2418	20019	11410	8609
	1987188		933	34987	16478	18509
Mungbean	1986/87	LVRIS	880	8448	2956	5493
	1987/88		557	5732	1867	3865
	1986/87	BP#2	636	6111	2707	3403
	1987/88		763	8112	1927	6185

BP#2 Total family labor, gross returns, labor and power cost, material cost, and total variable cost were higher for irrigated garlic than for irrigated rice during the 1986/87 dry season. Except for labor and power cost, the same results were observed during the 1987/88 dry season (Table **5).**

- Irrigated rice versus irrigated munghean.
  -- LVRIS. No difference in the mean values of economic parameters considered between irrigated rice and irrigated mungbean was observed during the 1986/87 dry season. During the 1987/88 dry season, gross returns, labor and power cost, material cost, and total variable cost were higher for irrigated rice than for irrigated muogbean. However, returns to material cost was lower for irrigated rice (Table 6).

Table 5. Comparison of economic parameters between irrigated rice and irrigated garlic under LVRIS and **BP#2**, 1986/87 and 1987/88 dry seasons.

	Difference			
	LVRIS		**BP#2**	
Parameters	1986/87	1987/88	1986187	1987/88
Average farm size (ha)	0.3 **	0.3 **	0.3 ns	0.2 **
Yield (kg/ha)	3314	2280	949	3227
Total family labor (md/mad/mmd)	–124 ns	–172 **	–250 *	95 **
Gross returns (₱/ha)	–4907 ns	–14968 **	–9533 •	–20429 **
Labor and power cost (₱/ha)	–156 ns	–252 ns	–1653 *	310 ns
Material cost @'/ha)	–3517 **	–6517 **	–4908 **	–7886 **
Total variable cost (₱/ha)	–3674 ns	–6769 **	–6561 **	–7576 **
Returns				
Above variable cost (₱/ha)	–1233 ns	–8190 **	–2978 ns	–12853 **
To labor and power cost (₱/₱)	–16.1 ns	–6.1 ns	29.6 ns	–5.5 ns
To material cost (₱/₱)	1.4 ns	0.7 ns	0.7 ns	–0.5 ns
To family labor (₱/md)	37.3 ns	–10.7 ns	15.4 ns	–52.6 ns

significant at **1% ns=not significant
'significant at 5%

Table **6.** Comparison of economic parameters between irrigated *rice and* irrigated nungbean under LVRIS and BP#2, 1986/87 and 1987/88 dry seasons.

	Difference			
	LVRIS		**BP#2**	
Parameters	1986/87	1987188	1986/87	1987188
Average farm size (ha)	0.3 **	0.24 **	0.3 ns	0.2 **
Yield (kg/ha)	4133	2497 **	2732	3397
Total family labor (md/mad/mmd)	26 ns	14 ns	–33 ns	34 ns
Gross returns (₱/ha)	4356 ns	4896 **	4375 ns	6446 **
Labor and power cost (₱/ha)	1995 ns	1593 **	1099 ns	3645 **
Material cost (₱/ha)	964 ns	1361 •	1043 ns	3330 **
Total variable cost (₱/ha)	2959 ns	2954 **	2142 ns	6975 **
Returns				
Above variable cost (₱/ha)	1397 ns	1943 ns	2227 ns	–529 ns
To labor and power cost (₱/ha)	–80.0 ns	–10.1 ns	–49.3 ns	–7.2 *
To material cost (₱/₱)	**-0.7** ns	–1.8 **	0.3 ns	–7.0 **
To family labor (₱/md)	**11.8** ns	15.9 ns	8.5 ns	**–24.4** ns

**significant at 1% ns=not significant
'significant at 5%

- — **BP#2.** During the 1986/87 and 1987/88 dry seasons, the same trend that was observed at LVRIS was observed at BP#2. However, returns to labor and power cost was lower for irrigated rice than for irrigated mungbean (Table 6).
- Irrigated garlic versus irrigated mungbean
  - — LVRIS. Material cost and total variable cost for irrigated garlic were higher than for irrigated mungbean during the 1986/87 dry season. During the 1987/88 dry season, family labor, labor and power costs, material costs, and gross returns were higher for irrigated garlic than for irrigated mungbean. However, returns to material cost for garlic was lower than for mungbean (Table 7).
  - — BP#2 . Similar results as that in LVRIS were observed during both dry seasons under BP#2, except material costs and returns above variable costs due to the unexpected increase in the price of garlic (Table 7).
- Irrigated mungbean versus rainfed mungbean.
  - — LVRIS. No differences in the economic parameters between irrigated and rainfed mungbean were observed during the 1986/87 dry season (Table 8). During the 1987/88 dry season returns to material cost and family labor were higher for irrigated mungbean than for rainfed mungbean.
  - — BP#2 . Yield during the 1986/87 dry season did not differ. During the 1987/88 dry season, yield, gross returns, returns to labor and power, returns to material cost, and returns to family labor were higher for irrigated mungbean than for rainfed mungbean (Table 8).

Performance of rainfed and irrigated mungbean did not differ because the crop can efficiently use the residual moisture after rice.

Limitations

- Depreciation costs of tools and equipment were not considered because farmers did not know the exact dates of purchase, costs, etc.
- Profitability of the different cropping patterns were not compared because of sudden increases in the price of garlic.

Table 7. Comparison of economic parameters between irrigated garlic and irrigated mungbean under LVRIS and BP#2, 1986/87 and 1987/88 dry seasons.

Parameters	Difference							
	LVRIS				BP#2			
	1986187		1987188		1986187		1987/88	
Average farm size (ha)	0.0		–0.1	ns	0.0		0.0	
Yield (kg/ha)	817		217		–1783		I70	
Total family labor (md/mad/mmd)	150	ns	193	**	–218	•	128	**
Gross returns (₱/ha)	9263	ns	19864	**	-13908	**	26875	**
Labor and power cost (₱/ha)	2151	ns	1845	**	–2752	**	3335	**
Material cost (₱/ha)	4481	**	7878	**	–5950	**	11216	**
Total variable cost (₱/ha)	6632	**	9723	**	–8703	**	14551	**
Returns								
Above variable cost (₱/ha)	2630	ns	10141	**	–5205	ns	12324	**
To labor and power cost (₱/₱)	–63.9	ns	–4.0	ns	78.9	ns	-1.7	ns
To material cost (₱/₱)	–2.1	ns	–2.4	**	0.4	ns	–6.5	**
To family labor (₱/md)	–25.5	ns	26.8	ns	6.9	ns	28.2	ns

“significant at 1%
‘significant at 5%
ns=not significant

Table 8. Comparison of economic parameters between irrigated and rainfed mungbean under **LVRIS** and BP#2, 1986/87 and 1987/88 dry seasons.

	Difference			
	LVRIS		BP#2	
Parameters	1986/87	1987/88	1986/87	1987/88
Average farm size (ha)	–0.3 **	0.1 ns	–0.2 ns	0.1 ns
Yield (kg/ha)	146	172	–99 ns	397 *
Total family labor (md/mad/mmd)	72 ns	–42 ns	44 ns	–55 *
Gross returns (₱/ha)	1541 ns	1772 ns	–797 ns	4103 *
Labor and power cost (₱/ha)	–867 ns	309 ns	–1082 ns	460 ns
Material cost (₱/ha)	496 ns	–140 ns	460 ns	–231 ns
Total variable cost (₱/ha)	–374 ns	168 ns	–622 ns	229 ns
Returns				
Above variable cost @'/ha)	1915 ns	1534 ns	–174 ns	3874 ns
To labor and power cost (₱/₱)	197.8 ns	12.0 ns	70.1 ns	7.5 *
To material cost (₱/₱)	0.1 ns	1.9 **	–1.8 ns	5.7 **
To family labor (₱/md)	–78.4 ns	52.6 *	86.0 ns	110.8 **

**significant at 1%
'significant at 5%
ns=not significant

Comments, Suggestions and Recommendations

- Yields of all crops studied during the 1987/88 dry season were lower compared with the yields during the 1986187 dry season due to unfavorable weather conditions. It is recommended that the same study be conducted during the 1988/89 dry season for more conclusive results.
- At BP#2, diversified crops using R-G-M cropping pattern did not use irrigation water from the system since farmers used pumps to irrigate garlic and mungbean.

Summary and Conclusions

Profitability of selected diversified crops under irrigated and rainfed conditions and their irrigated performance was compared with that of irrigated rice in the Laoag-Vintar River Irrigation System (LVRIS) and Bonga Pump No. 2 (BP#2) during the 1986/87 and 1987/88 dry seasons. Specifically, the study identified existing cropping patterns and compared their profitability; identified the most efficient means of utilizing family labor; determined the net returns to family labor and investment; and identified economic factors affecting crop diversification.

Two hundred seventy-three farmers under LVRIS and BP#2; 49 rainfed farmers and 14 wholesalers/retailers were interviewed during the 1986/87 dry season.

The 1987/88 dry season survey included 120 farmers with R-G-M CP and 40 farmers with R-R-M CP under LVRIS; 40 farmers with R-R-M CP and 40 farmers with R-G-M CP under BP#2; and 40 farmers planting rainfed mungbean.

Demographic and socio-economic characteristics, capital assets and cropping patterns were analyzed.

Predominant CPs identified were R-G-M and R-R-M.

Economic parameters between irrigated rice and selected diversified crops were compared and analyzed.

At LVRIS, during the 1986/87 dry season, material costs for irrigated rice was lower than for irrigated garlic. During the 1986/87 dry season, only material cost differed while during 1987/88 dry season, gross returns, total family labor, material costs, total variable costs and returns above variable cost were higher for irrigated garlic. The same results were obtained in farms under BP#2 during both dry seasons.

During the 1987/88 dry season, gross returns, labor and power, material and total variable costs were higher for irrigated rice than irrigated mungbean in both systems.

Material and total variable costs were higher for irrigated garlic than for irrigated mungbean in both systems during the 1986/87 dry season. During the 1987/88 dry season, gross returns, total family labor, labor and power cost, material cost and total variable cost were higher for imgated garlic than for irrigated mungbean in both systems. Also returns above variable costs was higher and returns to material costs was lower for irrigated garlic than for irrigated mungbean.

No difference between irrigated and rainfed mungbean was observed because of the crops' ability to **use** residual moisture in the soil.

Economic factors which affected crop diversification were:

- Market supply and demand;
- Unstable prices;
- High cost of input; and
- Quality of product.

Production, Credit and Marketing Schemes of Farms in ARIP I, BARIS, and MCIS, South Cotabato

Purisima G. Bacayag[1]

Abstract

A study on the production, credit, and marketing schemes of farms in the Allah River Irrigation Project I (ARIP I), Banga River Irrigation System (BARIS), and Mani Communal Irrigation System (MCIS) was conducted during the 1986/87 and 1987/88 dry seasons.

Comparative profitability of the different farms vaned. In BARIS, irrigated hybrid corn was equally as profitable as rice while in MCIS, irrigated hybrid corn was not as profitable as rice. Irrigated farms planted to hybrid and native corn yielded more resulting in more profit compared to rainfed corn farms.

Irrigation of corn in ARIP I did not perform well. Growing irrigated hybrid corn was not as profitable as growing rice; irrigated and rainfed corn did not also differ in performance.

Labor requirement in corn farms was equal with farms planted to direct-seeded rice. Availability of labor for all farm operations in rice and corn farms under the three irrigation systems was not a problem.

Generally, farmers obtained credit from non-formal credit institutions like neighbors, friends and local traders who usually charge high interest rates.

Production-related problems common to the farmers under the three irrigation systems were inadequacy of water supply, lack of capital, high interest rates for loans, low farmgate prices, and lack of transport facilities.

If adequate price incentives are available, irrigated hybrid corn can be as profitable as rice. Other non-rice crops may be adopted by farmers if the farmers are familiar with the cultural management of the crop and are assured of its market at a reasonable price.

Introduction

Decreasing water supply is one of the pressing problems in irrigation systems nowadays. Three irrigation systems in South Cotabato, namely, the Allah River Irrigation Project I (ARIP I), Banga River Irrigation System (BARIS) and the Mani Communal Irrigation Systems (MCIS) are faced with this problem especially during the dry season. To alleviate this problem, the management programmed some portions of the service area to be planted to diversified crops, particularly corn.

The economics of crop diversification under these irrigation systems was the focus of this study. Economic parameters studied were profitability, credit and marketing of corn compared with rice. The study was envisioned to provide benchmark information for related studies on crop diversification in irrigated rice-based systems.

The study was conducted to:

1. Compare the profitability of different farms under the three irrigation systems;
2. Determine the labor requirement and its availability for the different farm operations;
3. Identify the factors that influence decision-making among farmers;
4. Identify farmers' sources and amount of credit and marketing practices; and
5. Identify the problems encountered by farmers.

Methodology

Farmers covered by the service areas of the three irrigation systems were interviewed using a questionnaire interview schedule. Farmers under

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ARIP I and BARIS were interviewed during 1986/87 and 1987/88 dry seasons. However, farmers-under MCIS were interviewed during the 1986/87 dry season only due to rehabilitation activities in the system.

Respondent farmers were randomly sampled from each area. A total of 255 farmers were interviewed during the 1986/87 dry season 100 farmers under ARIP; 50 rice farmers, 50 irrigated (seepage) corn farmers, and 50 rainfed corn farmers under BARIS; and 35 rice farmers, 35 irrigated (seepage)corn farmers, and 35 rainfed corn farmers under MCIS.

On the other hand, 354 farmers were interviewed duringthe 1987/88 dryseason: 173 farmers under ARIP (84 rice farmers, 18 with irrigated [seepage] corn farms, 40 with rainfed [land converted] corn farms and 31 with rainfed corn farms); and 181 farmers under BARIS (84 rice farmers, 34 with irrigated [seepage] corn farms and 63 with rainfed corn farms).

All rice farms covered in the study were irrigated while the rainfed corn farms were farms within the vicinity of the service area which were dependent on rainfall. Irrigated (seepage) corn farms were farms within the service areas of the irrigation systems which used water which seeped-out from nearby irrigation canals and adjacent irrigated farms. Irrigated (seepage) corn farms were considered as irrigated in the study. Converted rainfed corn farms under ARIP I were farms planted to corn after irrigated rice.

Data gathered were analyzed using frequencies, percentages and comparison of means through the t-test.

Farm profitability was estimated based on grass returns (GR) using the formula:

$$GR = \sum_{i=1}^{n} PiXi$$

where: n = number of production outlets,
Pi = unit price of product disposed to the ith outlet, and
Xi = quantity of product disposed to the ith outlet.

GR is defined as the total value of a farmer's product valued at the time when the farmer disposes it. Harvester's and thresher's shares were considered as wet/fresh paddy since the farmer disposed it as undried harvest while paddy sold or used for consumption were considered dry.

Returns above variable cost (RAVC) was estimated as:

$$RAVC = GR - (MC + LPC)$$

where: GR = gross returns,
MC = material cost, and
LPC = labor and power cost.

Results and Discussion

Allah River Irrigarion Project *I*

Demographic characteristics. Generally, farmers under ARIP I were 40 to 47 years of age, male, married and with 20 to 24 years farming experience. Most farmers were able to finish at least grade six or at most second year high school. Their household consisted of the farmer himself, his wife and four to seven children. Farming served as their main source of livelihood.

Land holdings *and* utilization. Average farm size of farmers under ARIP I ranged from 1.10 to 1.74 hectares (Table 1). Farmers either owned or worked as tenants in the farm. Most farmers owned the land they tilled except those who tilled rainfcd corn farms who were mostly tenants. Rainfed corn farms were laterally distributed, i.e., located at the middle or tailend of laterals A-I, A-2, A-3, A-3a and A-extra. Irrigation water supply to these lateral areas was cut-off during the 1987/88 dry season. Majority of the farmers planted their crops on time.

Generally, an ARIP I farm was 97% planted during the wet season, and about 96-99% during the dry season. It was observed that irrigated corn farms were more utilized during the dry season than during the wet season. Under-utilization of irrigated corn farms during the wet season imply a need for levelling before the area can be fully irrigated. Since irrigated corn farms were planted to rice during the wet season, the whole area was not fully utilized. During the dry season, the whole area can be planted to corn, including high portions of the farm. Cropping patterns from 1985 to 1988 are shown in Table 2.

The main factors considered by farmers in selecting their farm size was the ability to maximize the use of the available area (Table 3). Other factors considered were availability of water, capital and credit facilities.

Farmers chose rice as a crop due to the availability of water, for family/home consumption and perceived higher economic returns (Table 4). The choice of corn as crop among farmers was determined on the pretext that ample irrigation

Table 1. Land holdings of farmers under ARIP I, 1986/87 and 1987/88 dry seasons.

Characteristics of Land Holdings	1986/87	1987/88			
	Irrigated Rice	Irrigated Rice	Irrigated Corn	Rainfed Corn (converted)	Rainfed Corn
Farm area (ha)	1.65	1.69	1.10	1.15	1.74
Tenure (%)					
Owned	44	42	56	35	42
Tenanted	38	36	39	50	39
Leased	8	19		15	13
Others	10	3	5		6
Lateral location (%)					
A	40	28			
A-I				2	13
A-2			33	5	10
A-3			33	28	26
A-3a			11	65	26
A-extra			23		19
B	11	14			
C	13	13			
D	6				
E	7	14			
Main canal	23	31			
Location within lateral (%)					
Head	16	33			13
Middle	59	33	56	22	45
Tail	25	33	44	78	42
No. of parcels (%)					
One	64	88	22	80	73
Two	30	9	61	18	18
Three or more	ti	3	17	2	9
Land utilization (%)	96	98	100	99	
Time of planting (%)					
Early	27		5	12	
On Time	ti5	81	90	67	
Late	8				

water is available. Corn farmers said they preferred to plant rice if there was enough water to irrigate their farms based on the following reasons: short cropping period of corn and high costs of seeds and other inputs especially for hybrid corn.

Farmers were unable to irrigate their farms because of the scheduled water cut-off in some laterals of ARIP I. Moreover, some farms were located at higher elevation which were difficult to irrigate. Farmers whose farms were earlier planted to irrigated rice, considered the residual moisture as sufficient to grow corn even without irrigation.

Profitability and labor requirement. During the 1987/88 dry season irrigated rice farms were the most profitable among the farms in ARIP I (Tables 5, 6a and 6b). Gross returns and returns above variable cost of rice farms were higher than irrigated farms planted to hybrid and native corn

Table 2. Cropping patterns of farmers under ARIP I, 1985 to 1988.

Type of Farm	1985/86 Wet	Dry	%	1986/87 Wet	Dry	%	1987/88 Wet	Dry	%
Irrigated Rice	ir	ir	58	ir	ir	93	ir	ir	99
	rr	rr	11	rr	rr	5	ir/rc	ir	I
	rc	rr	6	rc/ir	rc/rc	2			
	rc	rc	12						
	rc	ir	4						
	others		3						
Rainfed Corn (Converted)	rc	rc	62	ir	rc	40	ir	rc	15
	ic	rc	10	ir	ir	28	ir	rc	75
	ir	ir	15	rc	rc	8	irc	rc	5
	rc	f	5	irc	f	5	ir	irc	5
	irc	irc	2	others		19			
	ir	rrc	2						
	others		4						
Seepage Corn	sc	sc	8	sc	sc	13	ir	sc	100
	ir	ir	38	ir	ir	44			
	rc	rc	46	ir	rc	12			
	fallow		8	rc	rc	31			
Rainfed Corn	rc	rc	81	ir/rc	ir/rc	13	ir/rc	ir/rc	19
	ir	ir	6	rc	rc	65	rc	rc	55
	rc/rc	ir/rc	6	ir	ir	6	others		26
	others		6	others		16			

Legend: ir - irrigated rice; rr- rainfed rice; rc- rainfed corn; irc - irrigated rice+corn; rrc - rainfed rice+corn; sc- seepage corn

Table 3. Factors considered by farmers under ARIP I in determining farm size, 1986/87 and 1987188 drv seasons.

Factors	Rank 1986/87 Irrigated Rice	1987/88 Irrigated Rice	Irrigated Corn	Rainfed Corn (converted)	Rainfed Corn
Maximization of available area	I		1	2	2
Availability of water	2	1			
Ease of management	3				3
Availability of capital and credit			2	1	I
Availability of labor			3	3	
Risk involved in growing the crop		2			
Market demand of crop		3			

Table 4. Factors considered by farmers under ARIP I in determining what crop to plant, 1986/87 and 1987/88 dry seasons.

Factors	Rank 1986/87 Irrigated Rice	1987/88 Irrigated Rice	1987/88 Irrigated Corn	1987/88 Rainfed Corn (converted)	1987/88 Rainfed corn
Availability of water	I	1	1	1	1
For family home consumption	2	2			
High returns perceived	3	3			
Less production expenses				2	
Shorter cropping Season			2	3	
Availability of seeds and other inputs			3		3
Climatic condition					2

Table 5. Mean vield. cost and returns of farms under ARIP I. 1986187 and 1987/88 dry seasons

	1986/87	1987/88						
	Irrigated Rice	Irrigated Rice	Irrigated Corn		Rainfed Corn (Converted)		Rainfed Corn	
			Hybrid	Native	Hybrid	Native	Hybrid	Native
No. of samples	100	84	9	9	23	17	9	24
Ave. farm size (ha)	1.65	I.69	1.17	I.02	1.10	I.22	1.54	1.81
Yield (kg/ha)	4400	4016	3503	2283	3724	2870	2741	1748
Total family labor (md,mad,mmd)[a]	38	40	36	62	36	42	22	31
Gross returns (₱/ha)	10905	11936	7128	4339	7280	6272	5841	3998
Labor and power cost (₱/ha)	2569	2632	1450	648	1456	854	1262	746
Material cost (₱/ha)	2315	2184	2390	1203	2307	1106	2587	1065
Total variable cost (₱/ha)	4884	4816	3840	1851	3763	1960	3848	1812
Returns above variable cost (₱/ha)	6021	7120	3288	2488	3517	4312	1993	2187

[a]md - man-days
mad - man-animaldays
mmd - man-machinedays

Table 6a. Comparison between yield, cost of production and returns above variable cost of irrigated (IR) and rainfed (RF) crops in ARIP I, 1987/88 dry season.

	Difference					
	IR Rice versus IR Hybrid corn	IR Rice versus IR Native corn	IR Hybrid corn versus IR Native corn	IR Hybrid corn versus RF Hybrid corn	IR Native corn versus RF Native corn	IR Hybrid corn versus RF Hybrid corn (converted)
Yield (kg/ha)	313	1733	1420 *	962 *	535 ns	- 22 ns
Total family labor (md,mad,mmd)	3.6 ns	-22.4"	- 26.0 **	13.7 ns	30.6 **	- 0.3 ns
Gross returns (₱/ha)	4808 **	7597 **	2789 *	1287 ns	341 ns	- 153 ns
Labor and power costs (₱/ha)	1182 **	1984 **	802 **	188 ns	- 98 ns	- 7 ns
Material cost (₱/ha)	- 206 ns	981 **	1187 **	- 197 ns	138 ns.	83 ns
Total variable cost (₱/ha)	976 *	2965 **	1988 **	- 9 ns	40 ns	76 ns
Returns above variable cost (₱/ha)	3832 **	4632 **	800 ns	1296 ns	301 ns	- 229 ns

"md - man-days
mad - man-animal-days
mmd - man-machine days

** significant at 1%
* significant at 5%
ns not significaiit

Table 6b. Comparison between yield, cost of production, and returns above variable cost of irrigated (IR) and rainfed (RF) crops in ARIP I, 1987/88 dry season.

	Difference				
	IR Native corn versus RF Native corn (converted)	RF Hybrid corn versus RF Native corn (converted)	RF Native corn versus RF Native corn (converted)	RF Hybrid corn (converted) vs. RF Native corn (converted)	IR Rice (1986/87) vs. IR Rice (1987/88)
Yield (kg/ha)	870 ns	- 984 ns	- 1122 *	855 ns	384 *
Total family labor (md, mad,mmd)	19.7 *	- 14.0	10.9 ns	- 6.0 ns	- 1.1 ns
Gross returns (₱/ha)	- 1933 ns	- 1439 ns	- 2214 ns	1008 ns	- 1031 *
Labor and power costs (₱/ha)	- 206 ns	- 195 ns	- 108 ns	602 *	- 63 ns
Material cost (₱/ha)	98 ns	280 ns	- 40 ns	1201 **	301 **
Total variable cost (₱/ha)	- 109 ns	85 ns	- 148 ns	1803 **	238 ns
Returns above variable cost (₱/ha)	- 1825 ns	- 1525 ns	- 2126 ns	- 795 ns	- 1269 **

[a]md - man-days
mad - man-animal-days
mmd - man-machine days

** significant at 1%
* significant at 5%
ns not significant

Table 7. Labor requirement per hectare of farms under ARIP, 1986/87 and 1987/88 dry seasons.

Type of Labor	1986187 Irrigated Rice	1987/88 Irrigated Rice	Irrigated Corn	Rainfed Corn (converted)	Rainfed Corn
man-days	50.7 ds	52.7 ds	56.2	55.0	52.6
	77.6 tp	75.1 tp			
man-animal days	13.8	13.0	11.1	12.1	10.1
man-machine days	5.4	5.1	4.0	3.7	3.5

Legend: ds - direct-seeded (broadcasted)
tp - transplanted

because farmgate price for paddy was higher than for corn in 1987 and 1988.

Irrigated (seepage) corn farms did not differ in returns compared to converted rainfed and rainfed corn farms. However, yield and gross returns were higher in irrigated farms planted lo hybrid corn than irrigated farms planted to native corn. Returns above variable cost in farms planted to hybrid and native corn did not differ because of the higher production cost of hybrid corn.

Labor required to directly seed rice was less than planting corn; transplanting rice seedlings required more labor (Table 7). Labor required in irrigated and rainfed corn farms were the same. Additional labor was not needed in irrigated corn farms because irrigation water used came from water which seeped-out from nearby irrigated rice farms.

Farmers did not experience labor shortage regardless of what crop they planted (Table 8). The farmer and other members of his family provided the needed farm labor. Other people were hired to augment available family labor during the harvest season.

Production problems of farmers under ARlP I were lack of capital, inadequacy of water supply or rainfall, high cost of inputs and lasses due to pests and diseases.

Marketing. Farmers under ARlP I dry their produce before selling. However, 64% of the rice farmers sold their produce fresh/wet during the 1987/88 dry season (Table 9). Rice was graded according to moisture content and variety while corn was graded according to color. Farm produce was sold to local traders.

For the 1987/88 dry season produce corn in cobs was sold at ₱1.51 to ₱1.54/kg, shelled corn which was not dried at T'2.45 to ₱2.55/kg, and shelled dry corn at ₱3.02 to ₱3.08/kg. On the other hand, dry palay was sold at ₱3.48/kg while paddy, which was not dried, was sold at ₱3.00/kg. Since the farmgate price for palay increased, farm earnings during the 1987/88 dry season planting were higher than that during the 1986/87 dry season planting in spite of the higher yield during the earlier season.

Generally, farmers preterred to sell their produce to credible and accessible buyers as well as those who can provide them credit and can offer them a relatively high price. However, the major marketing problem of farmers under ARlP I was the low farmgate price for the produce. Due to lack of capital, farmers committed their crops as credit collateral resulting in their inability to bargain for a higher market price. Lack of transport facilities and poor roads were also some of the marketing constrains encountered.

Credit. During the 1987/88 dry season, 50-68% of ARIP I farmers availed cash loans ranging from ₱2,300 to ₱2,700 per corn farmer and from ₱3,600 to 73,900 per rice farmer (Table 10). Although loans were intended to serve as capital, 11-34% of it was utilized for non-agricultural or household purposes. Rice farmers obtained their loans from either their neighbors, friends, local traders or relatives. Corn farmers loaned from

Table 8. Availability of labor as perceived by ARIP I farmers, 1987/88 dry season.

	Response (% of sample size)																			
	Irrigated rice					Irrigated corn					Rainfed corn (converted)					Rainfed corn				
Farm Operations	P	E	F	M	NA	P	E	F	M	NA	P	E	F	M	NA	P	E	F	M	NA
Clearing the field	28	51	21			7	50	43			33	34	19	5	9	28	33	39		
Plowing	33	67				22	33	17			24	16	22			11	11	11	67	
Seedbed preparation	36	53	11																	
Harrowing	28	71	1			8	67	17	8		9	69	22			6	78	10		
Irrigating	5	85	10																	
Repair of dikes and canals	19	66	15																	
Furrowing						12	56	32			73	27				6	8	58	34	
Planting/transplanting broadcasting	38	62				47	53				13	85	2			37	57	6		
Uprooting and distributing of seedling	22	69	9																	
Thinning/replanting	34	66																		
Fertilizing	24	69	7			6	83	11			3	73	24			4	83	13		
Off-barring						67	33				3	76	21			94	6			
Hilling-up						76	24					12	28			87	13			
Spraying	31	59	10			83	17					45	55			50	50			
Weeding	32	63	5			75	25					50	50			3	87	10		
Harvesting	31	69				89	11				20	80				46	54			
Shelling/threshing				100					100				2	98					100	
Drying & bagging	7	86	7			56	44				58	42				69	31			
Hauling	6	82	6	6		50	30		20		45	34	3	18		40	60			
Average	24	64	6	6		43	37	8	12		20	46	22	11	1	34	41	11	14	

P - plenty
E - enough
F - few
M - available by machine
NA - not available

either chemical dealers, local traders, farmer's cooperative or relatives. Banks were also sources of loans. Among the sources mentioned, friends and relatives charged the highest interest; local traders and farmers cooperative ranked next in that order.

Table 11 shows the factors considered by farmers in ARIP I in choosing their sources of credit. The following were the sources of credit in order of preference: banks, local traders, and neighbors/friends. Banks charged the lowest interest rate among the three major sources.

Twenty-seven to 75% of the farmers availed of credit in kind during the 1986/87 dry season. In-kind credit consisted of fertilizer, seeds and pesticides. Rice farmers also loaned herbicides and fertilizer. Fertilizer occupied the bulk of credit in-kind compared with other farm inputs.

Loan-related problems were high interest rates charged by non-formal credit sources and delayed release of loans from formal credit institutions.

Table 9. Marketing practices of farmers under ARIP I, 1986/87 and 1987/88 dry seasons.

Marketing Practices	1986/87 Irrigated Rice	1987/88 Irrigated Rice	1987/88 Irrigated Corn	1987/88 Rainfed Corn (converted)	1987/88 Rainfed Corn
Pre-sale practices (%)					
A. drying	11	36	81	100	68
B. product classification according to:					
1. size	0	0	0	38	6
2. moisture content	71	61	87	82	73
3. variety	72	66	87	85	58
4. color	0	0	64	71	61
C. milling	2	I			
Condition of produce (%)					
1. dried palay	69	35			
2. fresh/wet palay	22	64			
3. milled rice/corn	2	I			
4. corn with cobs			28	8	26
5. shelled fresh/wet					3
6. shelled dry			72	92	71
Marketing outlets (%)					
1. local traders	73	98	100	95	96
2. NFA	16				
3. Samahang Nayon/ Farmers cooperative	3	I		5	4
4. Middlemen	2				
5. Other outlets	6	I			
Mode of payment (%)					
1. full cash	96	100	94	98	100
2. installment	2		6	2	
3. check	2				
Distance from farm to ***outlet (km)***	4.42	5.08	4.31	5.0	3.54
Mode of sale (%)					
1. delivered	60	44	44	44	52
2. picked-up	40	56	56	55	48
Marketing cost/farm (₱)	78.85	79.22	80.75	106.26	40.94

Table 10. Credit profile of AR1P I farmers, 1986/87 and 1987/88 dry seasons.

	1986/87	1987/88			
	Irrigated Rice	Irrigated Rice	Irrigated Corn	Rainfed Corn (converted)	Rainfed Corn
Formers who ovoiled of credit (%)					
1. cash	36	56	**50**	68	55
2. in kind	**24**	21	67	75	55
Amount of credit per cropping season (₱)					
1. cash	3876	3651	2381	2306	2634
2. in kind	1704	1259	934	2258	2288
Utilization of cash loons (% of total loon)					
1. agricultural purpose	**70**	72	66	89	72
2. non-agricultural purposes	30	28	34	11	28
Average annual interest					
1. cash loans	3066 (79%)	4667 (129%)	1728 (72%)	1184 **(51%)**	2136 **(81%)**
2. in kind	1608 (94%)	I48 (12%)	610 **(66%)**	1306 (57%)	**1150** **(51%)**

Table *11.* Factors considered by AR1P I farmers in their choice for source of credit, 1986/87 and 1987/88 dry seasons.

	Rank				
	1986/87	1987/88			
Factors	Irrigated Rice	Irrigated Rice	Irrigated Corn	Rainfed Corn (converted)	Rainfed Corn
Low interest rates	1	I	I	1	I
Availability of credit	2	2	3	3	
Convenience of availing credit	3	3	2	2	2
Security of loan					3

Banga River Irrigation System

Demographic profile. Majority of the farmers under BARIS were from **44** to 45 years old. Most of them were male, married and with **20** to 22 years of farming experience. Most farmers were able to finish at least grade six or at most, first year high school. Family size ranged from seven to nine. Farming was the main source of family income.

Land holdings and utilization. Average farm size of farmers under BARIS ranged from 1.21 to 1.60 hectares (Table 12). Farmers were either owners, tenants or leaseholders. Most rice fanners were leaseholders while most corn farmers whose lands were irrigated by seepage water were tenants. Most rainfed corn farms were either tilled by their owner or by tenants. Farms were laterally distributed. During the 1986/87 and 1987/88 dry seasons, however, most irrigated corn farms were found in laterals B, C, and along the main canal.

Like in ARIP I, most farmers under BARIS planted their cropsjust on time.

BARIS farms were 99 to **100%** planted during the wet season and 97 to 100% planted during the dry season. Major factors considered by rice fanners in determining the area to be planted were

Table 12. Land holdings of farmers under BARIS, 1986/87 and 1987/88 dry seasons.

Characteristics of Land Holdings	Irrigated rice		irrigated corn		Rainfed corn	
	1986187	1987188	1986/87	1987/88	1986/87	1987/88
Farm area (ha)	**1.60**	1.38	1.38	**1.21**	**1.55**	1.43
Tenure (%)						
Owned	34	24	30	20	52	29
Tenanted	32	29	40	53	34	53
Leased	34	**40**	26	20	14	16
Others	0	7	4	7		2
Lateral location **(%)**						
A	0	5	4		na	na
B	4	18	37	16	na	na
C	14	19	45	68	na	na
D	36	23	2	14	na	na
E	16	14	0		na	na
F	22	20	0		na	na
Main canal	8	1	12	3	na	na
Location within lateral (%)						
Head	34	33	40	22	na	na
Middle	48	33	46	33	na	na
Tail	18	33	14	45	na	na
Number ofparcels **(%)**						
One	80	74	62	**53**	66	**55**
Two	18	26	36	41	34	40
Three or more	2	**0**	2	6	0	**5**
Lnnd utilization (%)	97	**99**	98	100		
Time of planting (%)	-					
Early		***28***		30		31
On time		63		36		45
Late		9		34		24

Table 13. Factorsconsidered by farmers under BARIS indetermining thesizeoffarm, 1986/87 and 1987/88 dry seasons.

	Rank					
	Irrigated rice		Irrigated corn		Rainfed corn	
Factors	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
Availability of water supply	1	1	1		1	
Ease of management	2					3
Experience in the previous dry season	3		3		3	
Availability of planting materials and other inputs			2	3	2	2
Market demand of the produce			3	2		
Availability of capital		3				
Maximization of available area		2		1		1

Table 14. Factors considered by farmers under BARIS in determining what crop to plant, 1986187 and 1987188 drv seasons.

	Rank					
	Irrigated rice		Irrigated corn		Rainfed corn	
Factors	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
For family home consumption	1	1		2		
Availability of water	2	2	1	1		3
marketability of the produce	3		3		2	
Familiarity of the farmers in growing the crop			2		1	1
High returns perceived					3	
Suitability of crop		3				2
Ease of management				3		

the availability of water supply and convenience of managing the area (Table 13). Almost the same factors were considered by corn farmers except that their priority consideration was availability of seeds and other inputs.

The choice of rice as a crop among farmers was greatly influenced by their domestic need for rice (Table 14). Choosing between rice and corn, farmers preferred to plant the former if enough water was available.

Farmers under BARIS did not irrigate their farms because: 1. the area was at high elevation; 2. turnouts was not available; and 3. some farmers relied on seepage irrigation water.

Table 15 shows the cropping patterns employed by farmers under BARIS from 1985-88. Most rice farmers followed the pattern of planting irrigated rice during the wet and dry seasons, Majority of the corn farmers whose farms were either irrigated or rainfed planted corn during both wet and dry seasons.

Table 15. Cropping patterns followed by farmers under BARIS, 1985 to 1988.

	1985/86			1986/87			1987/88		
Type of Farm	Wet	Dry	%	Wet	Dry	%	Wet	Dry	%
Irrigated rice	ir	ir	77	ir	ir	74	ir	ir	99
	ir	sc	7	ir	sc	7	ir	irc	1
	others		16	others		19			
Seepage Corn	sc	sc	62	sc	sc	62	sc	sc	100
	rc	rc	6	rc	rc	6			
	ir	ir	9	ir	ir	24			
	ir	sc	12	others		8			
	others		11						
Rainfed Corn	c	c	81	c	c	84	c	c	92
	rc	rc	3	rc	rc	5	rc	rc	8
	others		16	others		11			

Legend: ir -irrigated rice
sc - seepage corn
irc -irrigated rice+corn
rc - rainfed corn
c - corn

Profitability and labor requirement. Planting irrigated hybrid corn in BARIS was more profitable than rice during the 1986/87 dry season (Tables 16 and 17). Although yields of hybrid corn and rice did not differ, gross returns and returns above variable cost for irrigated hybrid corn was higher than rice. The relatively high profitability of irrigated hybrid corn over rice was due to higher faringate price ofcorncoupled with low production cost (Table 18).

Table 16. Mean yield, cost and returns, BARIS, 1986187 and 1987188 dry seasons.

	1986/87					1987/88				
		Irrigated Corn		Rainfed Corn		Irrigated	Irrigated Corn		Rainfed Corn	
Items	Rice	Hybrid	Native	Hybrid	Native	Rice	Hybrid	Native	Hybrid	Native
No. of samples	50	43	7	34	16	84	34	no	33	30
Ave. farm size (ha)	1.MI	1.43	1.11	1.63	1.38	1.38	1.21	entry	1.42	1.46
Yield (kg/ha)	3802	4303	2863	3924	2614	3874	3977		3458	2491
Total family labor (md, mad, mmd)[a]	43	21	38	24	25	48	30		24	30
Gross returns (₱/ha)	8955	10685	6626	8802	5991	11081	9125	"	7086	5308
Labor and power cost (₱/ha)	1022	1087	707	873	601	2566	1642		1639	1047
Material cost (₱/ha)	2297	1774	826	1737	813	2276	2173		2115	1119
Total variable cost (₱/ha)	3299	2862	1532	2610	1415	4848	3815		3754	2166
Returns above variable cost (₱/ha)	5657	7824	5093	6192	4576	6240	5309		3332	3142

[a] md - man-days
mad - man-animal days
mmd - man-machine days

Table 17. Comparison between yield, cost of production and returns above variable cost of irrigated (IR) and rainfed (RF) crops in BARIS, 1986/87 dry season.

	Difference				
	IR Rice versus IR Hybrid corn	IR Rice versus IR Native corn	IR Hybrid corn versus IR Native corn	IR Hybrid corn versus RF Hybrid corn	IR Native corn versus RF Hybrid corn
Yield (kg/ha)	- 500 ns	939 *	1439 *	378 ns	249 ns
Total family labor (md,mad,mmd)	23 *	5 ns	- 17 **	- 3 ns	13 ns
Gross returns (₱/ha)	- 1730 *	2330 ns	4060 *	1883 *	634 ns
Labor and power cost (₱/ha)	- 85 ns	296 ns	381 ns	214 ns	105 ns
Material cost (₱/ha)	522 **	1471 *	949 **	38 ns	12 ns
Total variable cost (₱/ha)	431 *	1767 **	1330	252	117 ns
Returns above variable cost (₱/ha)	- 2161 **	563 ns	2730 ns	1632 *	517 ns

** significant at 1%
* significant at 5%
ns not significant

Table 18. Average farmgate price of rice and corn in BARIS, 1986/87 and 1987/88 dry seasons.

	Price (₱/kg)					
	Irrigated rice		Irrigated corn		Rainfed corn	
	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
Fresh/wet palay	2.34	2.95				
Dried palay	2.86	3.39				
Corn with cobs			1.65	1.53	1.60	1.55
Wet/fresh shelled corn			2.59	2.42	2.45	2.56
Dry shelled corn			3.07	2.95	3.18	3.01

Table 19. Comparison between yield, cost of production and returns above variable cost, HARIS. 1987/88 dry season.

	Difference	
	Irrigated Rice versus Irrigated Hybrid Corn	Irrigated Hybrid Corn versus Rainfed Hybrid Corn
Yield (kg/ha)	- 123	539 ns
Total family labor (md. mad, mmd)	17 **	7 ns
Gross returns (₱/ha)	1956 *	2038 **
Labor and power cost (₱/ha)	923 **	4 ns
Material cost (₱/ha)	103 ns	58 ns
Total variable cost (₱/ha)	1026 **	61 ns
Returns above variable cost (₱/ha)	930 ns	1977 **

** significant at 1%
* significant at 5%
ns not significant

During the 1986/87 dry season, irrigated hyhrid corn yielded more resulting in higher gross returns than irrigated native corn. However, with the high cost ofgrowing hybrid corn, returns above variable cost did not differ from that of native corn. Similarly, growing of irrigated hybrid corn was more profitable than rainfed hyhrid corn. Irrigation did not affect the profitability of growing nativc varieties.

During 1987/88 dry season, yield of irrigated hybrid corn was higher than rice but gross returns of the latter was higher due to a higher farmgate price (Table 19). In the same cropping season, gross returns in irrigated hyhrid corn was higher compared to rainfed hybrid corn.

Comparing the performance of BARIS farms between years, it was observed that performance of irrigated hybrid corn was better during the 1986/87 dry season (Table 20). On the other hand, gross returns of irrigated rice farms was higher during the 1987/88 dry season than during the 1986/87 dry season. But because of higher cost incurred in 1987/88, the returns above variable cost was not significantly higher than in 1986/87.

The trend of labor requirement for farms in BARIS was similar to that in ARIP I (Table 21). Farms which directly seeded rice bad the same labor requirements with corn farms; farms that transplanted rice had higher labor requirements. Irrigated corn farms had thesamelaborneeds with rainfed farms. No additional labor was used for irrigation since seepage irrigation water was used.

Availability of labor was not a problem in all types of farms in BARIS. On the average there was enough labor for all farm operations. The farmer and members of his family provided for the needed farm labor. Hired labor was only used to augment available family labor during the harvest season.

Inadequacy of water was the foremost problem of farmers under BARIS: problems on pests and diseases, high cost of fertilizer and chemicals, and lack of capital follow in that order.

Marketing. Farmers under BARIS dry their produce before selling them (Table 22). Farm produce are classified according to moisture content and crop variety before they are sold.

Table 23 shows the factors considered by farmers before they sold their produce. Most farmers sold their produce to a local trader.

Table 20. Comparison of yield, cost and returns between years (1986/87 and 1987/88) of irrigated rice and irrigated hybrid corn, ARIP and BARIS.

	ARIP	BARIS	
	Irrigated Rice	Irrigated Rice	Irrigated Corn
Yield (kg/ha)	3x4 *	- 72 ns	305 *
Total family labor (md,mad,mmd)	- I ns	- 4 *	- 9 ns
Gross returns (₱/ha)	- 1031 *	- 2125 **	1561 **
Labor and power cost (₱/ha)	- 63 ns	- 1563 **	- 555 *
Material cost (₱/ha)	301 **	21 ns	-.398 **
Total variable cost (₱/ha)	238 ns	- 1542 **	- 954 **
Returns above variable cost (₱/ha)	- 1269 **	583 ns	2514 **

** significant at 1%
* significant at 5%
ns = not significant

Table 21. Labor requirement per hectare, BARIS, 1986/87 and 1987/88 dry seasons.

	Irrigated Rice		Irrigated Corn		Rainfed Corn	
Type of Labor	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
man-days	54.9-ds 69.6-tp	55.1-ds 77.0-tp	, 57.4	54.5	52.7	54.8
man-animal days	12.2	10.7	10.9	9.9	9.8	10.0
man-machine days	5.1	5.0	3.7	4.0	3.0	3.6

ds - direct-seeded (broadcasted)
tp - transplanted

Table 22. Marketing practices of farmers under BARIS, 1986/87 and 1987/88 dry seasons.

	Irrigated Rice		Irrigated Corn		Rainfed Corn	
	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
Presale practices (%)						
Drying	90	62	98	94	80	76
Classification						
Size	0	0	0	0	0	0
Moisture content	100	81	96	95	98	79
Variety	100	16	10	9	18	13
Color	100	0	0	0	82	0
Milling		0		0		0
Condition of produce (%)						
Dried palay	90	62				
Fresh/wet palay	10	38				
Milled rice/corn	0	0				
Corn with cobs			2	6	20	27
Shelled dry corn			98	94	80	73
Marketing outlet (%)						
Local traders	79	98	94	94	94	100
NFA	4	2	0	0	0	0
SN & other farmers cooperative	17	0	4	0	4	0
Middlemen	0	0	2	0	2	0
Other	0	0	0	SMC-6	0	0
Mode of payment						
Cash	96	99	100	97	100	92
Installment	2	0	0	0	0	0
Check	2	I	0	3	0	8
Distance from farm to market outlet (km)	4.22	6.55	4.45	12.27	6.78	11.04
Mode of selling						
Picked-up	52	68	78	59	80	59
Delivered	48	32	22	41	20	41
Marketing cost (₱)	80	41	134	68	55	54

Table 23. Factors considered by farmers under BARIS in their choice of marketing outlet, **1986/87 and 1987/88** dry seasons.

	Rank					
	Irrigated Rice		Irrigated Corn		Rainfed Corn	
Factors	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
Price offered by the buyer	1	1	1	2	2	2
Marketing tie-up	2	2	2	1	1	1
Availability of credit from the buyer		3				
Mode of buying the product				3		
Familiarity and credibility of the buyer	3		3		3	3

Marketing problems encountered by farmers under **BARIS** were similar to those in ARIP 1 (Table **24).** Foremost of these problems was the low farmgate price for their produce relative to the price of inputs. Other problems were marketing tie-up, lack of transport facilities and lack of standards. Traders determined the quality of the produce sold without any standard to base their judgement. The *touch and feel* method was used to determine the produce's moisture content.

Credit. Majority of the **farmers** under **BARIS** availed of cash loans and in-kind credit (Table ***25).*** Corn farmers loaned higher amounts of both cash and credit in-kind compared to rice fanners. Cash loans of rice farmers ranged **from ₱1,500** to ₱2,000 while loans of corn farmers ranged from ₱2,500 to ₱4,000/cropping season. On the other hand, rice farmers availed credit in-kind ranging from ₱1,000 to ₱1,500 while that of corn farmers ranged from **₱1,800** to ₱2,500/cropping season. Although cash

Table 24. Marketing problems of fanners under BARIS, 1986/87 and 1987/88 dry seasons.

	Rank					
	Irrigated Rice		Irrigated Corn		Rainfed Corn	
Problems	1986/87	1987/88	1986/87	1987/88	1986/87	1987/88
Low farmgate prices	1	1	1	1	1	1
Existence of marketing tie-up	2	2	2	2	2	2
Lack of transport facilities		3		3		3
Lack of grading and standardization	3		3			
Distance of marketing outlet					3	

Table 25. Credit profile of farmers under BARIS, **1986/87** and **1988/88** dry seasons.

	Irrigated Rice		Irrigated Corn		Rainfed Corn	
	1986/87	**1987/88**	**1986/87**	**1987/88**	**1986/87**	**1987/88**
***Farmers who availed credit** (%)*						
Cash	70	64	58	62	54	50
In kind	44	50	52	56	54	60
Amount of credit per cropping season (₱)						
Cash	1611	1991	2590	4341	3081	2681
In kind	1427	1146	2401	2510	2084	1858
Utilization of cash loans (%)						
Agrl purposes	75	72	56	73	58	49
Non-agr'l purposes	25	28	44	27	42	51
Average annual interest						
Cash loans	1212	2660	977	2006	2453	1595
	(75%)	(132%)	(38%)	(46%)	(80%)	(60%)
Credit in kind	1108	542	679	997	1188	903
	(78%)	(48%)	(28%)	(40%)	(57%)	(49%)

loans were intended to purchase items for farm use, **25** to **44%** of it was used for household purposes. Non-formal credit institutions were the primary sources of cash loans. Such sources included local traders, neighbors/friends, and relatives who charged high interest rates. Local traders usually required the farmers a marketing tie-up which was more to the disadvantage of the farmer.

Choice for sources of credit in the order of preference were bank, local traders, relatives and neighbors/friends. Reasons for availing credit from these sources were low interest rates, and immediate availability and convenience of availing credit (Table *26).*

Rice farmers in BARIS availed of credit in-kind which included fertilizer, pesticides and herbicides while credit in-kind of corn farmers consisted of fertilizer and seeds. Fertilizer was the bulk of the farmers' credit in-kind.

The same loan-related problems as that in ARIP I were encountered by BARIS farmers. High interest rates and bank bureaucracy were the most common problems encountered.

Table 26. Factors considered by farmers under BARIS in their choice of credit source, **1986/87** and **1987/88** dry seasons.

	Rank					
	Irrigated Rice		Irrigated Corn		Rainfed Corn	
Factors	**1986/87**	1987/88	1986/87	1987/88	**1986/87**	**1987/88**
Low interest rates	1	1	1	1	1	1
Immediate availability of credit	2	3		3	2	2
Convenience of availing credit	3	2	2	2	3	3

Demographic characteristics. Generally, farmers under MCIS were older than farmers under ARIP I or BARIS; with ages ranging from 51 to 52 years. Most farmers were male and married with 24 to 26 years of farming experience. Most fanners under MCIS reached first year high school. Average family size was composed of seven to eight members. Farming was the family's main source of livelihood. Like in BARIS, MCIS farmers were categorized into three, rice farmers, irrigated (seepage) corn farmers, and rainfed corn fanners.

Land holdings and utilization. Average farm sizes in MCIS ranged from 1.33 to 1.81 hectares (Table 27). Farms were located at various laterals of the irrigation system and most were owned hy the farmers themselves. Unlike farms in ARIP I and BARIS, corn farms in MCIS were located at either head, middle or tail of almost all the laterals.

Farmers planted rice due to the availability of water supply, domestic need for rice and the marketability of palay in the local market. Corn farmers whose farms were imgated, planted corn because of the availability of water, perceived high returns of corn and the marketability of the produce. Like in BARIS, corn fanners could have opted for rice if irrigation water was enough,

Rice farmers considered the following in determining their farm's area to be planted: availability of water supply, market demand of the produce and experiences based on the previous dry season. Corn farmers considered experiences based on the previous dry season and the risk involved in growing the crop.

Profitability and labor requirement. Rice farmers under MCIS produced the highest crop yield (4.2 t/ha) and obtained the highest returns above variable cost (₱6,779/ha, Tables 28 and 29). Growing irrigated hybrid corn under MCIS was not as profitable as rice. Irrigated hybrid and native varieties yielded more than rainfed corn in MCIS. Although irrigated corn was not as profitable as rice, the high yield obtained indicated that corn is a potential crop for diversified irrigation systems.

Table 27. Land holdings of farmers under MCIS, 1986/87 dry season.

Characteristics of Land Holdings	Irrigated Rice	Irrigated Corn	Rainfed Corn
Farm area (ha)	1.43	1.33	1.81
Tenure (%I			
Owned	100	91	66
Tenanted	0	9	34
Leased	0	0	0
Others	0	0	0
Lateral location (%)			
A	17	18	n.a.
B	17	9	n.a.
C	17	14	n.a.
D	17	41	n.a.
E	17	18	n.a.
F	IS	0	n.a.
Location within lateral (%)			
Head	14	41	n.a.
Middle	66	45	n.a.
Tail	20	14	n.a
No. of parcels/farm (%)			
One	91	100	
Two	9	0	
Three or more	0	0	
Land utilization (%)			
Wet season	100	100	
Dry Season	100	100	

Table 28. Mean yield. returns above variable cost, and average price of produce, MCIS, 1986/87 dry season.

	Irrigated Rice	Irrigated Corn		Rainfed Corn	
		Hybrid	Native	Hybrid	Native
No. of samples	35	14	21	10	25
Ave. price (₱/kg)	2.57	2.23	2.12	1.86	2.10
Yield (kg/ha)	4174	2749	2428	2171	1765
Family labor (md, mad, mmd)	47	50	44	24	37
Gross returns (₱/ha)	10734	6091	5187	4104	3671
Total variable cost (₱/ha)	3954	2809	2035	2289	1630
Material cost (₱/ha)	2051	1570	919	1149	584
Labor and power cost (₱/ha)	1904	1239	1055	1140	1046
Returns above variable cost (₱/ha)	6780	3282	3152	1815	2041

Table 29. Comparison between yield, cost of production, and returns above variable costs of irrigated (IR) and rainfed (RF) crops in MCIS, 1986/87 dry season.

	Difference			
	IR Rice versus IR Hybrid corn	IR Rice versus IR Native corn	IR Hybrid corn vs. RF Hybrid corn	IR Native corn vs. RF Native corn
Yield (kg/ha)	1425**	1746**	578*	662*
Total family labor (md, mad, mmd)	-3.0 ns	3.5 ns	25.7**	5.9 ns
Gross returns (₱/ha)	4643**	5547**	1988*	1516 ns
Total variable cost (₱/ha)	1146*	1920**	520 ns	404 ns
Labor and power cost (₱/ha)	664**	848**	99 ns	9 ns
Material cost (₱/ha)	481*	1072**	422 ns	396**
Returns above variable cost (₱/ha)	3497**	3628**	1469*	1112*

** significant at 1%
* significant at 5%
ns = not significant

Rice and corn had the same labor requirement especially when rice was directseeded (Table 30). Farm operations involved in irrigated corn farms were the same with that of rainfed farms. Differences in man-days and man-animal days between the two farms was due to higher yields obtained from irrigated corn farms where more days were needed to harvest and shell the produce.

market outlets. Factors considered by farmers in choosingtheir buyers were: price offered, mode of payment for their produce and accessibility and honesty of the trader. Some local traders offered high prices for their produce comparable to that of the National Food Authority. Local traders also paid the farmers in cash.

Table 30. Labor reauirement per hectare. MCIS, 1986/87 dry season

Type of Labor	Irrigated Rice	Irrigated Corn	Rainfed Corn
1. man-days	40.5 ds 59.1 tp	49.5	42.6
2. man-animal days	9.I	10.8	1.2
3. man-machine days	2.8	3.0	2.5

Legend: ds . direct-seeded (broadcasted)
tp - transplanted

Production-related problems under MCIS included inadequacy of water supply, high cost of farm inputs and lack of capital (Table 31). Availability of labor was not a problem. The farmer and members of his family provided farm labor. Hired labor was used to augment existing family labor during peak seasons. Machinery was also used in the farm.

Table 31. Production problems of farmers under MCIS, 1986/87 dry season.

Problems	Rank		
	Irrigated Rice	Irrigated Corn	Rainfed Corn
Inadequacy of water supply	I		I
Lack of capital	2	3	3
High cost of chemicals	3	1	2
High cost of seeds		2	

Marketing. Farmers under MCIS dry their produce before selling them. Distance of the trading center from the farms was 7.5 to 10 km (Table 32). Local traders were the most popular

Table 32. Marketing practices of farmers under MCIS, 1986/87 drvseason.

Marketing Practices	Irrigated Rice	Irrigated Corn	Rainfed Corn
Condition ofproduct sold (%)			
Dried palay/ shelled corn	100	86	83
Wet-fresh/ shelled corn	0	0	0
Milled rice/corn	0	14	17
Marketing outlet (%)			
Local traders	60	100	100
NFA	17	0	0
Farmers' cooperative	8	0	0
Other	15	100	100
Mode of payment (%)			
Cash	100	100	100
Check	0	0	0
Installment	0	0	0
Distance of farm to market outlet (km)	1.7	9	10
Marketing cost/farm (₱)	80	114	152
Mode of sale (%)			
Delivered	54	42	54
Picked-up	46	58	46

Marketing problems encountered by farmers under MCIS were low price offered for their produce, lack of transport facilities, lack of product standards and marketing tie-up between traders and jeepney drivers.

Credit. Although lack of capital was one of the production problems in the area, only **14%** of the rice farmers availed of cash loans amounting to **₱3,900/cropping season** (Table 33). Most of the loans were secured from the rural and Philippine National Bank. Problems encountered by farmers in availing loans were high interest rates charged by the rural bank (67%/year) and the bank's bureaucracy.

None of the farmers claimed to have incurred loans in kind. Instead, truck and jeepney owners provided thefarmers' inputs such **as** seeds, fertilizer and otherchemicals withneither interest norprofit but with the condition that the vehicle's owner/ driver deliver the produce to the buyer of his choice. In this case, traders provided incentives to vehicle owners/drivers like a certain percentage of the cost per kilogram of the produce and reimbursement of the delivery fare. Inputs provided by truck owners were not considered loans; instead, they deprived the farmer the privilege to choose the buyers of their produce.

Table 33. Credit profile of rice fanners under MCIS, **1986/87** dry season.

Credit Profile	Irrigated Rice	Irrigated Corn	Rainfed Corn
Farmers who availed of credir (%)			
Cash	14	0	0
In kind	0	0	0
Amounr of credit/cropping season for rhose who availed of credit) (₱)	3,900		
Utilization of cash loan (%)			
Agricultural purpose	100		
Nnon-agricultural purpose	0		
Average interest per cropping (₱)	522		
Sources of credir (%)			
PNB	20		
Rural Bank	67		
Neighbors/friends	13		
Annual interest rates (%)			
PNB	28		
Rural Bank	67		
Neighbors/friends	5		

Yield and Profitability of Farms Under ARIP I, BARIS and MCIS

During the 1986/87 dry season, farms in ARIP I produced the highest yield of irrigated rice, farms in MCIS and BARIS ranked next in that order (Tables 34 and 35). Gross returns were higher in farms in MCIS and ARIP I than farms in BARIS. However, farms under the three irrigation systems did not differ in the returns above variable cost because of the higher production cost incurred in farms under ARIP I and MCIS. Irrigated hybrid corn performed better under BARIS than under MCIS.

During the 1987/88 dry season, there were do differences observed on the performance of both irrigated rice and imgated hybrid corn planted in ARIP 1 and BARIS. Production performance of farms in MCIS was not compared because it was not included during the 1987/88 dry season survey.

Table 34. Comparison of yields, costs and returns between irrigated rice and irrigated hybrid corn under ARIP, BARIS, AND MCIS, 1986/87 dry season.

	Irrigated Rice			Irrigated Hybrid Corn
	MCIS versus ARIP	BARIS versus ARIP	BARIS versus MCIS	BARIS versus MCIS
Yield (kg/ha)	- 226 ns	- 587 **	- 371 ns	1554 **
Total family labor (md, mad, mmd)	8.1 ns	5.0 ns	- 3.1 ns	- 28.7 **
Gross returns (₱/ha)	- 171 ns	- 1950 **	1779 **	4594 **
Labor and power cost (₱/ha)	- 666 **	- 1567 **	- 901 **	- 152 ns
Material cost (₱/ha)	- 264 *	- 19 ns	245 ns	204 ns
Total variable cost (₱/ha)	- 930 **	- 1585 **	- 656 *	53 ns
Returns above variable cost (₱/ha)	759 ns	- 364 ns	- 1123 ns	4541 **

** significant at 1%
* significant at 5%
ns = not significant

Table 35. Comparison of yield, costs and returns between irrigated rice and irrigated hybrid corn under ARIP and BARIS, 1987/88 dry season.

	Irrigated Rice	Irrigated Hybrid Corn
	ARIP vs BARIS	ARIP vs BARIS
Yield (kg/ha)	142 ns	- 295 ns
Total family labor (md, mad, mmd)	- 8.1 ns	5.6 ns
Gross returns (₱/ha)	855 ns	- 1997 ns
Labor and power cost (₱/ha)	66 ns	- 193 ns
Material cost (₱/ha)	- 91 ns	217 ns
Total variable cost (₱/ha)	- 25 ns	24 ns
Returns above variable cost (₱/ha)	880 *	- 2021 *

** significant at 1%
* significant at 5%
ns = not significant

Conclusions and Recommendations

Irrigated hybrid corn showed good potential as an alternative crop to irrigated rice for farms in BARIS and MCIS. Growing corn can be equally as profitable as irrigated rice considering labor requirements. Although irrigated hybrid corn was not as profitable as irrigated rice in MCIS, irrigated corn farms produced better yield and obtained more profit than rainfed farms. Therefore irrigation had a significant impact in hybrid and native corn production in MCIS.

Irrigation of corn in ARIP I during the 1987/88 dry season did not show significant effects. Irrigated hybrid corn production was not as profitable as rice. Production did not, however, differ between irrigated and rainfed corn farms.

Irrigated corn production can be as profitable as rice provided there are adequate price incentives. One of the reason on why irrigated corn planted during the 1987/88 dry season was not as profitable as that during the 1986/87 dry season was due to the decrease in farmgate prices. Price for palay in 1987/88 increased but prices for corn decreased.

Other non-rice crops maybe adopted by farmers if they are familiar with production aspects of the crop and its market is assured at a commensurate price.

Socio-Economic and Water Management Practices Affecting Diversified Cropping Among Farmers Served Within the TASMORIS Area

Alfredo S. Reyes and P. Dionisio R. E. Reyes[1]

Abstract

A socio-economic survey conducted in the Tarlac-San Miguel-O'Donnel River Integrated Irrigation System (TASMORIS) revealed the potential for crop diversification in the area. Soil, climate and location were ideal for diversification. Non-rice crops like corn and sunflower can be alternative crops to rice. Plantingnon-rice cropscanincreaseland utilization to as much as 90% as well as net profits to as much as 1.5 times (i.e., corn after rice) than that from rice. Although no differences were observed between rice and the identified non-rice crops, there is still a need to further evaluate their potential as alternate to rice. With proper financial and technical assistance similar to that of the Dry Season Irrigation Management Project (DSIMP), non-rice crops can he a substitute for rice monoculture.

Importance/Significance of the Study

The Philippine economy has always been characterized as predominantly agricultural, i.e., 65% of the total populace is dependent on agriculture as their source of livelihood. Agriculture accounts for 60% of national exports and about 33% of gross national product (PCARRD Monitor, May 1986).

Considering agriculture as the economy's hackhone, there is then a need to strengthen agricultural crop production. A crucial element in crop production is water. Its availability, as well as, its proper management and use is essential for crop production. Water comes from the atmosphere in the form of rain or precipitation, the earth's surface like rivers, streams and other bodies of water, and from groundwater.

The seasonal precipitation in the country is largely due to varied weather systems. Generally, rainfall is unevenly distributed and often cannot adequately meet moisture requirements for a successful crop growth (Philippines Recommends for Irrigation Wafer Management, 1982).

Providing upland crops with adequate water, especially during the dry months when solar radiation is high, increases production. This, coupled with removal of excess water during the rainy season, is the main consideration of water management.

Water and soil moisture are essential for continuous lowland cropping. Distinct wet and dry seasons in most parts of the country make year-round supply impossible. At the height of summer in upland as well as lowland areas, crop production is hardly possible especially where communal irrigation is non-existent (PCARRD Monitor, October 1986).

In areas with low annual rainfall and even in areas where total annual rainfall is fairly high but where little or no rain falls during the crop-growing season, irrigation is still needed to grow crops.

The success, therefore, of an irrigation project could only be measured by its agro-socio-economic impact on its beneficiaries and on the national economy. It is therefore necessary to consider agricultural development in implementing irrigation projects (Balog Multi Purpose Project Pre-Appraisal Study, NIA, 1987).

Study Area

The Tarlac-San Miguel-O'Donnel River Integrated Irrigation System (TASMORIS) is one

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of the country's national irrigation system. It was chosen as the study area because of its potential for crop diversification. The National Irrigation Administration (NIA) identified corn and sunflower as potential alternative crops for rice during its pilot testing of the Dry Season Irrigation Management Project (DSIMP) during crop year 1986/87. The area is accessible and proximate to Metro Manila; thus, enabling farmers to market their pro[redacted]

TASMORIS was formed from the merger of three irrigation systems in Tarlac, namely, the Tarlac River Irrigation System (TARRIS), the San Miguel-O'Donnel River Irrigation System (SMORIS) and the Camiling River Irrigation System (CAMRIS). TASMORIS has a service area of 9,580 hectares, 8,843 hectares of which are adequately imgated. The service area covers seven towns in Tarlac namely La Paz, Victoria, Capas, Tarlac and certain parts of Concepcion, Pura, and Gerona.

Statement of the Problem

A survey was conducted to determine the reasons of farmers in selecting crops and cropping patterns, as well as, land utilization practices in areas where proper control over available water was not possible either due to technical or non-technical (i.e., socio-economic, institutional) constraints.

Objectives of the Study

The study was focused on the socio-economic profile of farmers served by TASMORIS. It also identified and documented the economics of cropping patterns employed by farmers in irrigated and rainfed areas of TASMORIS.

Specifically, the study aimed to:

1. Determine the socio-economic profile of farmers served by TASMORIS;
2. Identify crops other than rice which farmers have been planting for crop diversification:
3. Determine the economics of crop diversification, specifically cost, yield and gross and net returns;
4. Identify problems and situations affecting farmers' production in relation to marketing, price and credit; and
5. Propose recommendations that can help solve the problems identified.

Methodology

A questionnaire-interview schedule was prepared with the assistance of IIMI. The questionnaire-interview schedule was pre-tested before the survey was conducted.

A list of farmers under TASMORIS was obtained from the NIA office in Tarlac to facilitate identification of respondents.

Surveys for the first and second phases were conducted in the dry season, 1986/87 and 1987/88, respectively. Data gathered were compiled, tabulated and statistically analyzed

One hundred twenty-five respondents were interviewed during the first phase. Respondents consisted of farmers under TASMORIS whose farms were located at specific laterals within the system, 31 other farmers from the DSIMP and 25 local traders. However, DSIMP was terminated after the first phase survey and data from the traders were only included during the same phase. Maintaining the original set of respondents, the second phase added to its sample size, 60 farmer-respondents. Nine respondents were replaced due to relocation. Additional respondents were also interviewed.

Results and Discussion

To obtain an overview of the extent of crop diversification in the system, the first survey interviewed specific farmers based on their location within the system. The second survey interviewed the same farmers but concentrated on cropping patterns and the economics of growing crops like rice, corn and mungbean.

Table 1 presents the demographic profile of the sample population. Average ages of the farmers, their wives and children ranged from 46-50 years, 4247 years and 16-17years, respectively. On the average, a farmer finished grade five while his wife finished grade six. A farmer's child was able to finish a year in high school or at least graduated from elementary. Family size is relatively small, with an average of three children or a farm household of five. Generally, a farmer has been farming for 25 years.

Rice-rice cropping pattern was predominant among farmers located at the portions closest the canals or dam. Other cropping patterns employed in the area which involved non-rice crops were rice-irrigated corn and rice-rainfed munghean. Rice-rainfed mungbean cropping pattern was pre-

Table 1. Demographic profile of farmer respondents under TASMORIS.

	Crop Years	
	1986/87	1987/88
Age (in years)		
Farmer	50	46
Farmer's Wife	47	42
Children	17	16
Educational Attainment (in grade levels)		
Farmer	5	6
Farmer's Wife	5	6
Children	7	7
Number of Children	3	3
Farming Experience (years)	26	24

dominant among fanners located at the tail portion of the system while the rice-irrigated corn cropping pattern was adopted by farmers at the middle section. Another cropping pattern involved the combination of both rice and non-rice crops planted during the same cropping season. Crops were either planted in relay in the same area or simultaneously, with plots planted to various crops. Some farmers employed cropping patterns like rice-rainfed corn and rice-irrigated munghean.

The choice of crops or cropping patterns depend on a number of factors: Rice-rice farmers considered sufficient irrigation water supply and location of their farm; Rice-irrigated corn farmers attributed their reasons to experience; and insufficient water prompted rice-rainfed mungbean farmers to adopt such cropping pattern. Soil and crop factors as well as market conditions and availability of inputs were also considered by the farmer in choosing his cropping pattern.

Table 2 shows percentage of land utilization per cropping pattern. During 1986/87 dry season, land utilization regardless of cropping pattern decreased. From almost 100% during the 'wet season this was reduced to about one half to three fourths during the dry season. Rice-rice cropping pattern had the highest land utilization during the 1987/88 dry season due to theirlocation within the system, i.e., located closest to the source (the dam). However, land utilization under the rice-rice pattern increased during the 1987/88 dry season. Though still lower than the wet season utilization, an increase from the previous crop year was observed. The increase in land utilization for rice-non-rice cropping pattern was due to the campaign on massive corn planting initiated by the government.

Table 3 presents average yield/ha, price/kg and gross returns/ha during the 1986/87 and 1987/88 dry seasons of the farms in TASMORIS. Rice exhibited the highest yield during the 1986/87 dry season. Rice also generated the highest gross returns in spite of the low farmgate prices for that year. However, irrigated corn proved better in terms of production during 1987/88 dry season. In spite of a decrease in farmgate prices, corn farms obtained an average gross return of PI 1,876/ha. Yields of irrigated and rainfed munghean were low during both 1986/87 and 1987/88 dry seasons. Higher prices for munghean did not result in high gross returns.

Comparably, rainfed munghean had better yield than irrigated mungbean in both dry seasons. Although there was a higher price for irrigated mungbean, rainfed munghean still earned a larger gross return. Farmers said that it was not the lack of water which determined the good harvest for

Table 2. Percent land utilization, TASMORIS, 1986/87 and 1987/88 dry seasons.

Cropping Pattern	1986/87 Wet Season	1986/87 Dry Season	1987/88 Wet Season	1987/88 Dry Season
Rice - Rice	98	72	98	99
Rice - Non-Rice	100	58	100	90
Rice - Rice+Non-Rice	91	58	92	76

Table 3. Total yield, average price and gross returns of farms in TASMORIS, 1986/87 and 1987/88 dry seasons.

	1986/87			1987/88		
	Total Yield (kg/ha)	Price (₱/kg)	Gross Returns (₱/ha)	Total Yield (kg/ha)	Price (₱/kg)	Gross Returns (₱/ha)
Irrigated Rice	**3165**	**2.84**	**9131**	**2814**	**3.15**	**8855**
Irrigated Corn	**2361**	**3.63**	**8557**	**347s**	**3.43**	**11876**
Semi-irrigated Mungbean	**I26**	**9.13**	**1241**	**100**	**10.00**	**998**
Rainfed Mungbean	**207**	**9.50**	**1972**	**I24**	**9.83**	**1241**
Rainfed Corn	**1096**	**4.15**	**4308**	—	—	—

rnungbean but the timeliness of water supply. Water is crucial especially during the reproductive stage of mungbean. Lack of water is detrimental to flower and pod formation. Similar cases were observed in the Ilocos project sites [2]. Farmers preferred not to use irrigation water if it would be delayed.

Mean returns above variable costs [3] to irrigated and rainfed crops are shown in Table 4. During the 1986/87 dry season, returns to rice and irrigated corn were not different. However, during the 1987/88 dry season, there was a marked increase in returns to irrigated corn. Returns to mungbean also showed the crop's potential for planting in rainfed areas rather than in irrigated areas. Although yields decreased during both crop years, rainfed mungbean was still more profitable than imgated mungbean. This further support the observation that it is not only the amount of water that counts in mungbean production, but the timeliness of its availability.

Table 4. Summary of mean returns above variable cost (₱/ha) of irrigated and rainfed crops, TASMORIS, 1986/87 and 1987/88 dry seasons.

	1986/87	1987/88
Irrigated Rice	**4314**	**4930**
Irrigated Corn	**4371**	**7471**
Semi-Irrigated Mungbean	(62)	**(404)**
Rainfed Munghean	**686**	**43**
Rainfed Corn	**1407**	—

Differences between mean returns of crops for both crop years were determined (Table 5). Rice and irrigated corn have higher returns above variable cost than irrigated mungbean during the 1986/87 dry season. Returns above variable cost to irrigated corn was higher than irrigated mungbean during the 1987/88 dry season. Results, therefore, indicate that corn is potential crop for diversification in the area. Returns for rainfed mungbean still were higher than that of irrigated mungbean, though the difference was not significant. Therefore, mungbean is recommended for planting in rainfed than irrigated areas in TASMORIS.

[2] First Progress and Interim Reports, TA *859* Philippines, Study on Irrigation Management for Crop Diversification, August 1987 and September 1988 respectively.
[3] Can also be referred to as returns.

Table 5. Summary of 1-test results for yield and returns above variable cost of different irrigated (Ir) and Rainfed (Rf) crops, TASMORIS, 1986187 and 1987188 drv seasons.

	Differences	
	Yield (kg/ha)	Returns above variable cost (₱/ha)
1986/87		
Ir. Rice vs. Ir. Mungbean	na	**4,436** **
Ir. Rice vs. Ir. Corn	na	**3** ns
Ir. Corn vs. Ir. Mungbean	na	**4,433** **
Ir. Corn vs. RI. Corn	1,265 ns	**2,964** ns
Ir. Mungbean vs. Rf. Mungbean	(81)ns	**(748)** ns
Rf. Corn vs. Rf. Mungbean	na	**721** ns
1987/88		
Ir. Rice vs. Ir. Corn	na	**(2,641)** ns
Ir. Rice vs. Ir. Mungbean	na	**5,334** ns
Ir. Corn vs. Ir. Mungbean	na	**7,975** *
Ir. Mungbean vs. RI. Mungbean	**(24)**ns	**(447)** ns

** - Significant at 1%
* - Significant at 5%
ns - Not significant
na - Not applicabie (not comparable)

Table 6 shows the average costs of labor, power, and materials incurred by farmers during the 1986/87 and 1987/88 dry seasons. Total costs incurred for labor, power and materials was equal to the total variable cost of production. A shift in investment proved to be a disadvantage on rice production. With 54% of the total variable cost invested on labor and power during the 1986/87 dry season, returns were higher than when 61% of the total variable cost was invested on material inputs. Therefore, the amount of farm inputs should not only be increased but also properly managed to maximize production. Also irrigated non-rice crops, specifically irrigated corn, depend on farm inputs, rather than on labor and power. Farm operations like primary and secondary land preparation and crop management for non-rice crop production require intensive farm labor and machinery. However the demand for farm labor and power was offset by abundant family labor since the dry season months coincided with the schools' vacation. There were also transient farmers from adjacent areas who were hired to help plant either a second or third crop.

For capital, farmers availed of credit for farm inputs. Neighbors and friends were the common sources of credit. Farmers preferred to borrow from these sources due to their familiarity with the lenders and the relative ease of obtaining the needed money. Compared with local money lenders and traders who charge interest rates of 13-18% per month, neighbors and relatives charged lower interest rates, sometimes even interest-free. However, most farmers still preferred to obtain loans from banks.

Farmers who avail of credit with high interest rates opted to plant less input-intensive crops like native corn and mungbean. They also reduced the size of their farms commensurate to the available capital. Expected profitability of the crop was also a factor in determining farm size.

Price was the foremost consideration in marketing farm produce. Other marketing factors considered were transportation cost and familiarity or established rapport with the trader.

Marketing related problems identified were low and fluctuating prices, lack of transportation facilities, and distance of the market to the farm.

Production problems of farmers under TASMORIS were more water related. There was either lack of water downstream, excess water upstream, or inefficient delivery of water to some areas.

Table 6. Production cost of farms in TASMORIS, 1986/87 and 1987/88 dry seasons.

	Labor and Power Cost (₱/ha)	Percent of Total Expenses	Material Cost (₱/ha)	Percent of Total Expenses
1986187				
Irrigated Rice	2,580	54	2,177	46
Semi-Irrigated Mungbean	363	28	939	72
Irrigated Corn	1,752	42	2,432	58
Rainfed Corn	1,191	41	1,405	59
Rainfed Mungbean	444	35	842	65
1987-1988				
Irrigated Rice	1,523	39	2,402	61
Semi-Irrigated Mungbean	400	29	1,002	71
Irrigated Corn	1,788	42	2,517	58
Rainfed Corn	—	—	—	—
Rainfed Mungbean	336	28	862	72

Dry Season Irrigation Management Project (DSIMP). Pilot test for the DSIMP was launched in November 1986. The project aimed to: (1) alleviate the problem of inadequate water during the dry season by planting low-water-requiring-crops like corn, mungbean and sunflower, and (2) assist small farmers increase their production and consequently their income.

The project provided technical and financial support to farmers who were members of an irrigators' association and who were willing to act as cooperators. Technical and financial support came from the National Irrigation Administration (NIA), and other government and private agencies, Farmers were extended technical support through seminars and training courses on production and management of non-rice crops and on water management practices. Individual loans amounting to ₱2,700 were granted to farmer cooperators to purchase farm inputs like fertilizer and insecticides and payment for farm labor. Payment for irrigation services and association fees were also included in the loan. Loans were paid back to NIA upon disposal/sale of farm produce. In cases where farmers encountered marketing problems, NIA provided for outlets for their produce with the farmers having the option to solicit better buyers.

DSIMP covered two irrigation systems, namely, the Sta. Monica Communal Irrigation System (SMCIS) in Concepcion, Tarlac and TASMORIS, in Talaga, Capas, Tarlac. There were 13 farmer-cooperators from SMCIS and 11 from Talaga. All cooperators were considered as respondents. For comparison, seven rice farmers who were not covered by the project were also interviewed.

Farmers' profile under DSIMP was similar to farmers under TASMORIS. However, DSIMP farmers had a smaller household size. Average age of children of farmers under DSIMP was 12 years old.

Of the three crops planted by farmers under DSIMP, corn yielded the highest. In spite of the low farmgate price for corn, higher gross return was obtained than from other crops (Table 7). Compared with rice, irrigated corn still performed better. Irrigated mungbean in SMCIS had better yield than those in TASMORIS. Returns, however, show that although corn production exhibited high gross earnings, net returns from it were very low (Table 8). Similar results were obtained for irrigated mungbean in SMCIS. Most of the expenses incurred in growing non-rice crops were on farm inputs like fertilizers and insecticides (Table 9).

Table 7. Total yield, price and gross returns of crops under DSIMP, 1986/87 dry season.

	N	Total Yield (kg/ha)	Price (₱/kg)	Gross Returns (₱/ha)
Crops with DSIMP Support				
SMCIS				
Munghean	8	277	10.00	2,710
Sunflower	3	312	12.00	3,741
Talaga				
Sunflower	1	800	13.50	10,800
Corn	6	2,071	3.80	1,870
Mungbean	6	36	9.42	334
Crops w/o DSIMP Support				
Rice	7	2,736	2.60	7,135

Table 8. Summary of mean returns above variable cost of selected crops in SMCIS and TASMORIS, with or without DSIMP support, 1986/87 dry season.

	N	Returns above Variable cost (₱/ha)
Crops with DSIMP Supporr		
SMCIS		
Mungbean	8	803
Sunflower	3	1,255
Talaga		
Sunflower	1	4
Corn	6	16
Mungbean	6	(1,123)
Crops w/o DSIMP Supporr		
Rice	7	3.561

Table 9. Production cost of farms in SMCIS and TASMORIS, with or without DSIMP support, 1986/87 dry season.

	Labor and Power Cost (₱/ha)	Percent of Total Expenses	Material cost (₱/ha)	Percent of Total Expenses
Crops with DSIMP Support				
SMCIS				
Mungbean	808	41	1,159	59
Sunflower	585	24	1,901	76
Talaga				
Sunflower	1,750	41	2,550	59
Corn	328	14	2,368	86
Mungbean	514	35	943	65
Crops w/o DSIMP Supporr				
Rice	2,173	61	1,401	39

Table 10. Summary of t-lest results for yield and return above variable cost of diffcrcnt irrigated (Ir) and rainfed (Rf) crops in SMCIS and TASMORIS with DSIMP support, 1986/87 dry season.

	Differences	
	Yield (kg/ha)	Returns above variable cost (₱/ha)
Within systems		
SMCIS		
Ir. Rice vs. Ir. Mungbean	na	2,758 *
Ir. Rice vs. Ir. Sunflower	na	2,307 *
Ir. Mungbean vs. Ir. Sunflower	na	(452) ns
Talaga		
Ir. Corn vs. Ir. Munghean	na	(6,297) **
Across systems		
SMCIS		
Ir. Mungbean vs. Talaga Ir. Mungbean	242 **	(1,926) **

** -Significant at 1%
* - Significant at 5%
ns - Not significant
na - Not applicable (not comparable)

Differences between crop yield and returns are shown in Table 10. Rice performed better over irrigated mungbean and sunflower in SMCIS while irrigated corn performed better than irrigated mungbean in TASMORIS. Mungbean production in SMCIS was more profitable than in TASMORIS.

The pilot test identified sunflower as a potential crop for diversification. Although there were only four farmer-cooperators who planted sunflower, favorable results were obtained. Farmers under TASMORIS who planted sunflower obtained gross returns of 66% higher than when planting rice. In SMCIS, planting sunflower was more profitable than irrigated mungbean with net earnings of ₱1255 or 56% more than mungbean (Table 8). Sunflower commands a higher unit price than other crops. However, there is still a need to study the market potential of sunflower. Feed millers and mixers are the only buyers of sunflower. Sunflower seeds are used as feed boosters for game fowls.

Even if most farmer cooperators sought the assistance of NIA to sell their produce, marketing was still a problem. Most market outlets were located far from the farm, thus, farmers incurred high transportation cost.

Conclusions and Recommendations

Results of the study showed that there is a high potential for crop diversification in TASMORIS. Further research on the adaptability and profitability of growing non-rice crops like corn and sunflower in the areas covered by TASMORIS should be conducted. The potential of sunflower as an alternative crop for diversification and its possible uses other than feed must also be studied.

With adequate support in the form of technical know-how, financial assistance and exploring market outlets, growing corn and sunflower can be alternative sources of income during the dry season. Comparable, if not, greater profits than from rice can be obtained with proper crop management for corn and sunflower. Projects like DSIMP can catalyze crop diversification.

There is a need for research in land utilization and farm labor to serve as benchmark information in determining profitability of non-rice crops for crop diversification.

When asked whether they would plant non-rice crops during the 1988/89 dry season, farmers responded positively provided financial and technical assistance are available. Without these incentives, farmers would just fallow their land.

Implications For Policy of the Studies on Profitability of Irrigated Non-rice Crop Production: A Synthesis

Marietta S. Adriano[1]

Abstract

Economic aspects and profitability of irrigated diversified cropping during the dry season are presented herein. Results of cost and returns analyses in the production of different crops during the 1986/87 and 1987/88 dry seasons showed garlic as the most profitable non-rice crop for farms in the Laoag-Vintar River Imgation System and Bonga Pump No. 2 Irrigation System. The returns to garlic production exceeded that of irrigated rice. Increases in the yield as well as in the returns to hybrid corn production under the Tarlac-San Miguel-O'Donnel Irrigation System indicate the potential of hybrid corn as an alternative crop to rice. Likewise, the returns to onion production under the Upper Talavera River Irrigation System have been greater than that of irrigated rice. Planting irrigated rice under the Allah River Irrigation Project was more profitable than planting irrigated hybrid or native corn. On the other hand, corn production under the Banga River Irrigation System performed better than irrigated corn under the Allah River Irrigation Project.

Implications and recommendations for policy considerations focus on the provision of support services designed to give farmers more incentives to grow the crops identified lo have a comparative advantage in the area. A credit facility/relending program for diversified cropping is essential to provide farmers the needed production loans. The total variable cost in the production of garlic and onions ranged from two to four times higher than that incurred in irrigated rice. Higher production costs may either prevent farmers from planting these crops or may force them to plant a very limited area as compared with rice. It is further recommended that the relending program charge market interest rates since the problem of farmers is more on access to credit rather than the magnitude of the interest rate charged. There is a need to provide post-harvest facilities for the storage and/or secondary processing of corn, onions and garlic. The private sector is expected to own and operate these facilities. The government will provide the support services related to institutional strengthening of cooperatives, soliciting sources for technical and capital assistance on the management/operations of the facilities, and research and development (R&D) on post-harvest processing technologies. R&D activities may include: survey and identification of non-rice crops which can be produced at a comparative advantage; the breeding of open-pollinated corn and new varieties of peanuts with shorter growth period; and the design of farm tools for labor-intensive non-rice crops such as onions and garlic. A strengthened extension program should help bridge the gap between agricultural research and the utilization of research results by the farmers. The national infrastructure program must also include the requirements of a crop diversification program. The private sector, with the full support of the government, must be encouraged to develop the local market and to explore foreign markets for diversified crops. Coherent and consistent government policies are needed to give impetus to diversified cropping, which must be considered only as a starting point of a more general and encompassing agricultural diversification program.

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Introduction

The findings reported in this paper are part of an interim report on the "Study on Irrigation Management for Diversified Crops" submitted in September **1988** by the International Irrigation Management Institute (IIMI) to the Asian Development Bank (ADB). The study is a technical assistance grant (TA **859** PHI) to the Government of the Philippines, primarily funded by the ADB. The research was conducted by IIMI in collaboration with the National Irrigation Administration (NIA), the consortium of state colleges and universities which form part of the research network coordinated by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), and the Department of Agriculture (DA). This report presents the economic aspects and profitability of irrigated diversified cropping. It draws heavily from research results obtained from the state colleges and universities, namely: Mariano Marcos State University, Pampanga Agricultural College, Central Luzon State University, and University of Southern Mindanao. The paper is divided into three sections: (1) the profitability of selected irrigated crops during the dry season; (2) the economic constraints to the adoption of diversified cropping; and (3) the implications and preliminary recommendations for policy consideration.

Profitability of Irrigated *Diversified* Crops

The profitability of irrigated diversified cropping in the six irrigation systems covered **are** discussed. The Mani Communal Irrigation System is being rehabilitated and has been excluded from the seven irrigation systems as originally planned. Results of the study presented include the **cost** and returns analysis by crop within each irrigation system for the 1987/88 dry season; a comparison of the cost and returns of rice and diversified crops between the 1986/87 and 1987/88 dry seasons; and a comparison of the profitability of the crops across some of the irrigation systems.

Tables 1 and 2 show the mean yield and mean returns above variable cost[2], respectively, of irrigated and rainfed crops planted under the different irrigation systems during the 1986/87 and 1987/88 dry seasons. The significant results of yield and returns comparison of different crops within each system and across systems for 1986/87 and 1987/88 dry seasons are summarized in Table 3. A comparison of farmgate prices, by crop, in the different irrigation systems during the two dry seasons is presented in Table **4.**

Table 1. Summary of mean yield (**kg/ha**) of irrigated and rainfed crops planted in the different systems during the 1986/87 and 1987/88.

	Rice		Mungbean		Corn				Garlic		Onion	
					Hybrid		Native					
	1987	**1988**	**1987**	**1988**	**1987**	**1988**	**1987**	**1988**	**1987**	**1988**	**1987**	**1988**
					Irrigated ***Crops***							
LVRIS	**5013**	**3034**	**880**	**537**	—	—	—	—	**1700**	**754**	—	—
BP#2	**3361**	**4159**	**636**	**763**	—	—	—	—	**2418**	**933**	—	—
TASMORIS	**3165**	**2814**	**126**	**100**	**2361**	**3475**	-	—	—	—	—	—
UTRIS	**3172**	**3238**	—	—	—	-	—	—	—	—	**10660**	**9557**
ARIP	**4400**	**4016**	—	—	—	**3713**	—	**2283**	—	—	—	—
BARIS	**3802**	**3874**	-	—	**4303**	**3997**	**2863**	—	—	—	—	—
					Rainfed Crops *(within* or near ***the systems)***							
LVRIS		—	**734**	**365**	—	—	—	—	—	—	—	—
BP#2	—	—	**734**	**365**	—	—	—	—	—	—	—	—
TASMORIS	—		**207**	**124**	**1096**	—	—	—	—	—	—	—
UTRIS	—	—	—	—	—	—	—	—	—	—	—	—
ARIP	—	—	—	—	-	**2741**	—	**1748**	—	—	—	—
BARIS	—	—	—	—	**3924**	**3458**	**2614**	**2491**	—	—	—	—

[2]The term *returns* used in subsequent paragraphs refers to mean returns above variable cost. **Similarly, the term *yield* and *prices* used in the text refer to mean yield** and mean prices.

Table 2. **Summary** of mean returns above variable cost (₱/ha) of irrigated and rainfed crops planted in the different systems during 1986/87 and 1987/88 dry seasons.

	Rice		Mungbean		Corn: Hybrid		Corn: Native		Garlic		Onion	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
						Irrigated Crops						
LVLRIS	6890	5807	5493	3865	—	—	—	—	8123	14006	—	—
BP#2	5630	5656	3404	6185	—	—	—	—	9060	17249	—	—
TASMORIS	4374	4930	-62	-404	4371	7572	—	—	—	—	—	—
UTRIS	8185	6463	—	—	—	—	—	—	—	—	16766	41082
ARIP	6021	7120	—	—	—	3288	—	2488	—	—	—	—
BARIS	5657	6240	—	—	3282	5309	3152	—	—	—	—	—
						Rainfed Crop (within or near the systems)						
LVLRIS	—	—	3578	2311	—	—	—	—	—	—	—	—
BP#2	—	—	3578	2311	—	—	—	—	—	—	—	—
TASMORIS	—	—	686	43	1407	—	—	—	—	—	—	—
UTRIS	—	—	—	—	—	—	—	—	—	—	—	—
ARIP	—	—	—	—	—	1993	—	2187	—	—	—	—
BARIS	—	—	—	—	1815	3332	2041	3142	—	—	—	—

Preliminary results of the cost and returns analyses in the production of the different crops in the six irrigation systems during 1986/87 and 1987/88 dry seasons are as follows:

- Garlic is the most profitable non-rice crop for farms in the Laoag-Vintar River Irrigation System (LVRIS) and Bonga Pump No. 2 Irrigation System (BP#2). Yield and returns to garlic production under BP#2 have been higher than those under LVRIS during the 1986/87 and 1987/88 dry seasons. Generally, garlic farmers under BP#2, apply more farm inputs and pay about ₱900 more per hectare for irrigation. Farmers also have better control over irrigation water, which accounts for higher yields and profitability of farms in BP#2. Under LVRIS and BP#2, the returns to garlic production exceeded that of rice. Since garlic is planted only in irrigated areas, it is indeed an alternative crop to irrigated rice.

- Increases in the yield as well as in the returns to hybrid corn in the Tarlac-San Miguel-O'Donnel Irrigation System (TASMORIS) during the 1987/88 dry season compared with the previous year, indicate the potential of hybrid corn as an alternative crop to rice. No significant difference between the returns to irrigated corn and irrigated rice were observed during the 1986/87 and 1987/88 dry seasons.

- The returns to onion production under the Upper Talavera River Irrigation System (UTRIS) were greater than that of rice for the past two dry seasons. In spite of the 10% decrease in the yield of onions during the 1987/88 dry season, the 217% increase in its price still made production more profitable than rice. Even at the 1986/87 price level and with the 10% reduction in yield in 1987/88, farmers would still have a positive returns of ₱6,116/ha. Therefore, irrigated onions can he an alternative crop to irrigated rice.

- A dry season rice crop under the Allah River Irrigation Project (ARIP) is more profitable than a crop of either hybrid or native corn. In terms of yield and returns, rice under ARIP performed better than rice

Table 3. Summary of significant t-test results for yield and returns above variable cost of different irrigated (Ir) and rainfed (Rf) crops within each system and across systems.

System	Crops Compared	Differences: Yield (kg/ha)	Differences: Returns above variable cost (₱/ha)
	Crop Year 1986/1987		
Within the System			
TASMORIS	Ir. Rice vs. Ir. Mungbean	na	4436**
	Ir. Munghean vs. Ir. Corn	na	-4433**
BARIS	Ir. Rice vs. Ir. Hybrid Corn	na	-2167**
	Ir. Hybrid Corn vs. Rf. Hybrid Corn		1632*
	Ir. Hybrid Corn vs. Ir. Native Corn	1439*	
	Rf. Hybrid Corn vs. Rf. Native Corn	1310*	
Across Systems			
BARIS/ARIP	Ir. Rice vs. Ir. Rice	-597**	
	Crop Year 1987/1988		
Within the System			
LVRIS	Ir. Rice vs. Ir. Garlic	na	-8199**
	Ir. Garlic vs. Ir. Munghean	na	10141**
BP#2	Ir. Rice vs. Ir. Garlic	na	-12853**
	Ir. Garlic vs. Ir. Mungbean	na	12324**
	Ir. Munghean vs. Rf. Mungbean	397*	
UTRIS	Ir. Rice vs. Ir. Onion	na	-34918**
TASMORIS	Ir. Corn vs. Ir. Mungbean	na	7975*
ARIP	Ir. Rice vs. Ir. Hybrid Corn	na	3832**
	Ir. Rice vs. Ir. Native Corn	na	4632**
	Ir. Hybrid Corn vs. Ir. Native Corn	1420**	
	Ir. Hybrid Corn vs. Rf. Hybrid Corn	962*	
	Rf. HybridCorn vs. Rf. Native Corn	993*	
BARIS	Ir. Hybrid Corn Vs. Rf. Hybrid Corn		1977**
	Rf. Hybrid Corn vs. Rf. Native Corn	967**	
Across Systems			
BP#2/LVRIS	Ir. Rice vs. Ir. Rice	1125**	
	Ir. Garlic vs. Ir. Garlic	178**	
	Ir. Munghean vs. Ir. Mungbean	225**	2320**
ARIP/BARIS	Ir. Rice vs. Ir. Rice		880*
	Ir. Hybrid Corn Vs. Ir. Hybrid Corn		-2021*
	Rf. Native Corn vs. Rf. Native Corn	-744*	

** = significant at 1%
* = significant at 5%
na = not apphcable

under the Banga River Irrigation System (BARIS) during the two years of the study. However, BARIS conditions are more ideal for corn production - irrigated hybrid corn and rainfed hybrid and native corn as well, compared with ARIP.

Table 4. Comparison of farmgate prices (₱/kg) of different crops planted within each system during 1986/87 and 1987/88 dry seasons.

System	Crop		Price 1986/87	Price 1987/88	Difference
LVRIS	Rice	Mean	2.58	3.50	-0.92**
		SD	0.31	0.55	
	Garlic	Mean	10.33	34.31	-23.98**
		SD	3.25	9.28	
	Ir. Mungbean	Mean	9.71	10.70	-0.99**
		SD	1.99	0.88	
	Rf. Mungbean	Mean	9.28	11.07	-1.79**
		SD	0.55	0.79	
BP#2	Rice	Mean	2.88	3.50	-.62*
		SD	0.83	0.00	
	Garlic	Mean	8.19	37.87	-29.68**
		SD	3.48	9.98	
	Ir. Mungbean	Mean	9.68	10.66	-0.98**
		SD	0.55	0.65	
	Rf. Mungbean	Mean	9.28	11.07	-1.79**
		SD	0.55	0.79	
TASMORIS	Rice	Mean	2.84	3.15	-0.31**
		SD	0.37	0.20	
	Ir. Corn	Mean	3.63	3.43	0.20**
		SD	0.05	0.17	
	Ir. Mungbean	Mean	9.13	10.00	-0.87 ns
		SD	2.29	0.25	
	Rf. Mungbean	Mean	9.50	9.83	-0.33 ns
		SD	0.45	0.55	
UTRIS	Rice	Mean	3.07	3.49	-0.42**
		SD	0.27	0.34	
	Onions	Mean	2.92	6.35	-3.43**
		SD	1.01	2.15	
ARIP	Rice	Mean	2.41	2.%	-0.49**
		SD	0.43	0.26	
BARIS	Rice	Mean	2.36	2.87	-0.51**
		SD	0.48	0.29	
	Ir. Hybrid Corn	Mean	2.49	2.29	0.20*
		SD	0.39	0.31	
	Rf. Hybrid Corn	Mean	2.29	2.08	0.21*
		SD	0.37	0.45	
	Rf. Native Corn	Mean	2.33	2.09	0.24 ns
		SD	0.45	0.53	

**=significant at 1%,
* = significant at 5%
ns = not significant

Economic Constraints to the Adoption of Diversified Cropping

Constraints in adopting diversified cropping in the six irrigation systems are classified into four broad areas of considerations: land utilization/cropping patterns, labor availability, credit/financing, and post-harvest handling/marketing.

Land Utilization/Cropping Patterns. A wet season crop of rice has been traditionally part of the cropping patterns employed by farmers under the irrigation systems covered. Rice has been traditionally planted as a wet season crop because: (1) the farmer wants to be assured of meeting the rice requirements of his farm household, even that of his married children and (2) the location and level of his field relative to other farms is such that it is bound to receive both rain and irrigation water in excess of what a non-rice crop would require. In cases when the harvest from the wet season rice crop is not enough to supply the rice requirement of the household, farmers may opt to have a dry season crop of rice. In general, non-rice crop production is feasible only during the dry season.

Experience, knowledge of the technology on the production of the non-rice crop, and perceived profitability are crucial factors in the fanner's decision to plant a particular crop. Such case hold true with onion fanners under UTRIS, garlic fanners under LVRIS and BP#2, and corn farmers under BARIS.

Planting of diversified crops was more popular among farmers under LVRIS and BPR. Farmers under TASMORIS were the least knowledgeable and least experienced with regard to planting a non-rice crop during the dry season. The limited water supply under TASMORIS often forces farmers, especially at the tail-end of laterals, to leave their farms fallow after the wet season rice crop.

The onset of rainfall triggers the start of land preparation for the wet season rice crop. Rainfall supplements the water supplied by the irrigation system. Accordingly, timeliness in farm operations is not entirely within the farmer's control. A late wet season planting means less turn around time for land preparation and subsequent delays in the harvest of the first dry season crop. The chain of delays may cost a farmer his second dry season crop. Such a case happened to fanners who followed a rice-rice-mungbean cropping pattern under LVRIS during the 1987/88 dry season.

Establishment of the dry season crop may be delayed due to the time required to drain the field before it becomes suitable for land preparation. Problems on drainage, heavy clay soils, seepage from surrounding fields, and a previous rice crop, deter an early and timely land preparation for the next crop. Under such circumstances, the fanner may instead decide to plant rice, if he can be assured of irrigation water, rather than wait until his field becomes workable.

Availability of Labor. Labor was the least limiting among the constraints to diversified cropping. Farmers engaged in the production of onions and garlic which are both labor-intensive crops, did not encounter any problem on the supply of labor. Hired labor provided by migrant workers from nearby rainfed areas augmented the labor needs for such crops.

However, high material cost (e.g., seeds, fertilizers and chemicals) for onions and garlic limited both the size of the plots planted and the number of farmers engaged in the production of thesecrops. Should the size of the area be expanded as a response to the provision of an agricultural credit facility and/or a more attractive export market, labor will become a problem in the production of these labor-intensive crops. Furthermore, as more agricultural lands are irrigated, the usual flock of migrant workers from what used to be rainfed areas will no longer be available as a supplementary labor force.

Credit/Financing. Most of the fanners indicated their preference for banks as their source of credit/financing for their production loans, followed by relatives, friends/neighbors, and traders. However, majority of the farmers finance their crop production through informal lenders, i.e., friends/neighbors, relatives and traders. Except for some onion farmers under UTRIS, whose source of financing are banks, most farmers do not borrow from the banks for their financing needs in spite of their preference for banks and the lower interest rates charged for bank loans. Because of past arrearages incurred in previous government programs (e.g., Masagana 99 and Maisagana program), some farmers are no longer elegible to borrow from the banks, although their number cannot be determined.

Among the informal sources of credit, traders were the least preferred/approached by farmers. Farmers believed that in addition to the high interest rates charged by traders, the prices paid for their harvest were lower than what others would usually pay. Moreover, fanners felt obliged to sell their produce to traders who financed their production loans.

The availability of financing for crop production partly determines the kind of crop to plant (whether input-intensive as in garlic and onions) and the size of the area allocated for the crop. A number of financing arrangements have emerged in the production of onions and garlic. Repayments for loans were denominated in terms of cavans (50 kg) of palay per ₱100-loan, or a sharing based on the quantity of seeds (for onions) or seed pieces (for garlic) loaned to farmers at planting time.

Post-Harvest Handling/Marketing. Post-harvest handling of onions and garlic poses more problem than corn and palay due to their perishable nature. Moreover, post-harvest technology for these crops is not as established as the technology for grains. like rice and corn. Primary processing (drying) of grains, in general, appears to be a problem only during the wet season when not enough post-harvest facilities are available.

The perishable nature of non-grain crops result in greater price fluctuations even during the harvest season (Table 4). Abrupt changes in the prices of onions and garlic continue to accrue after the harvest season, as compared to the stable prices of rice and corn. Similarly, price fluctuations between the years were more pronounced in non-grain crops.

Implications and Preliminary Recommendations for Policy Consideration

Once the crops which can he profitably grown in a specific area have been identified, the government and private sectors can encourage crop diversification through the provision of support services designed to give incentives to farmers. The kind of support services to he provided will depend on the degree of adoption of the crop in the locality.

(I) A ***credit facility/relending program*** for diversified cropping is essential in order to provide the farmers the needed production loans for crops identified to have a comparative advantage in the area. Credit availability is a constraint in the production of hybrid corn in **BARIS**, onions in UTRIS, and garlic in **LVRIS** and BP#2. The total variable costs in the production of garlic and onions ranged from two to four times greater than the total variable costs in the production of rice. An incremental difference of ₱7,000 to ₱8,000 per hectare in total variable costs may either prevent farmers from planting garlic or onions, or may force them to plant a much smaller area compared with that for rice. Sizes of farm plots planted to garlic in LVRIS averaged only 39% of the plot size planted to rice. Likewise, farm plots planted to onions in **UTRIS** averaged only **55%** of the size of rice farm areas.

Total variable costs ranging from ₱12,000 to ₱16,000 per hectare in the production of garlic and onions, when borrowed from informal credit lenders, would be a sizeable amount in terms of sourcing it and in repaying the loan inclusive of interest. It is, therefore, recommended that the relending program charge market interest rates since the problem of farmers is more on access to credit rather than the magnitude of the interest rate charged. Furthermore, a market interest rate of about 18% are much lower than the more than 100% annual interest rate paid by farmers to informal lenders. While the government may initially provide the credit relending program, direct lending should be through the privately owned rural and commercial/development banks.

(2) There is a need to provide ***post-harvest facilities*** for the storage and/or secondary processing of corn, onions and garlic. Aside from prolonging the shelf life of these crops, product diversification through processing will increase the incomes of farmers. Farmgate prices in March-April 1988 for garlic at **LVRIS** and BP#2 were ₱34.31/kg and **₱37.87/kg,** respectively. Most farmers sold their garlic within a month after harvest due to the need to repay loans, to meet household expenditures, and lack of storage facilities. The retail price of garlic in Metro Manila, barely four months after harvest, had increased to ₱168/kg. While farmgate prices at harvest cannot be compared with Metro Manila retail prices four months later, the difference in the prices shows who profits most from garlic production. Similarly, farmers under **UTRIS** received only **₱6.35/kg** of onions during the time of harvest while retail prices for onions was ₱26/kg five months later in Metro Manila. Local traders/retailers of these commodities make more profits than the farmer producers, who have to overcome more risks in growing the crops. A complementary component to the post-harvest facilities would be a ***quedan*** guarantee fund scheme which would issue negotiable warehouse receipts. Farmers, based on their financial needs and the prevailing prices, could decide to monetize/sell the warehouse receipts if and when necessary.

In line with the privatization program of the government, the post-harvest facilities and the ***quedan*** guarantee fund could be established through private initiative with the government providing the support services related to institutional strengthening of cooperatives, sourcing of technical assistance on the management/operations of the facilities and in further research and development on post-harvest processing technologies. The ownership and operations of post-harvest facilities is expected to be a private sector endeavor. Government may temporarily engage in this endeavor only in the absence of a willing private investor and when the facilities are deemed as necessary support components.

(3) Research and development *(R&D)* efforts from both the government and private sectors covering different areas of concern can boost the adoption of diversified cropping, such as the following:

- Survey and identification of crops other than rice which can be produced at a comparative advantage in specific localities in the country, with emphasis on profitability. ast government efforts have tended to equate increased production with improved productivity and profitability;

- Breeding for improved varieties of native corn, which appears to be a profitable crop in BARIS and which has total variable costs of only *58%* of what is needed for hybridcorn. The cost ofnativecornseedsin BARIS and ARIP is only 14% the cost of hybrid corn seeds. Furthermore, farmers can produce their own seeds of native corn while hybrid seeds have to be bought every planting season;

- Design of new farm tools and/or modification in the design of existing tools for the cultivation of crops identified as suitable for diversified cropping. The amount of family labor involved in garlic production is two to three times the amount incurred in rice production. Similarly, contribution of family labor in onion production is about four times greater than in rice production. The use of appropriate tools in the cultivation of onions and garlic, both labor-intensive crops, would reduce the drudgery of farm operations involved and the labor required; and

- Generation of technologies for primary and secondary post-harvest processing of non-grain crops, including the design of appropriate storage facilities/equipment.

(4) A *strengthened extension program* should help bridge the gap between agricultural research and the utilization of research results by the farmers. Past government extension programs were focused on the production aspects of grain crops, specifically rice and corn. A broader extension program, which includes the production, post-harvest processing and marketing of other potentially profitable crops, would offer farmers the opportunity to consider other alternative crops. Farmers must have access to an agri-business approach to crop diversification.

(5) There is a need to include the *infrastructure* requirements of a crop diversification program in the national infrastructure program. Aside from irrigation, infrastructures like farm-to-market roads, telecommunication facilities and markets will encourage farmers to produce crops other than rice. The agricultural and industrial sectors must closely coordinate with each other in determining their respective priority projects. The choice as well as the phasing of the implementation of the projects must complement each other for optimum benefits to the target clientele.

(6) The private sector, with the full support of the government, must be encouraged *to* develop the local market and to exploreforeign markets for diversified crops. There cannot be a better incentive for farmers to produce a specific crop than an assured market. The Philippine embassies abroad are in a position to help the local exporters make the necessary contacts with potential importers.

(7) *Coherent* and consistent *government policies* are needed to give impetus to diversified cropping. There has to be a realization of the basic need to reallocate resources as part of the development process in agriculture. The decrease in the real prices of rice during the past decade indicates a need for such adjustments which should not be met through support measures designed to artificially keep rice prices above their market-clearing levels. Increasing the flexibility of cropping systems through diversified cropping can provide a less costly adjustment or response to changing domestic and world market conditions'.

(8) Diversified cropping may be only a starting point to a moregeneral and encompassing *agricultural diversification program.* This program should

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'Schuh. G.E. and S. Barghouti. Agricultural Diversification in Asia. Finance and Development. June 1988. International Monetary Fund and the World Bank, Washington, D.C.

include other relatively more income-elastic agricultural products like livestock, poultry and fruits, which would have better market demand and higher potential for increasing farm incomes.

The Integrated Rural Finar ing (IRF) program of the Department of Agriculture, which considers the credit requirement of the entire farm household instead of the production of only one crop for one season, may be considered an agricultural diversification program. The IRF program may provide credit for a combination of livestock-crop farm enterprise for one to three years.

It is also recommended that a multi-disciplinary approach be undertaken towards a crop diversification program. No single government or private agency nor one discipline is in a position to plan and implement the program. Relatedly the concerned sectors **must** consolidate their efforts, build on gains from experiences, and continue to design an appropriate crop diversification program.

Next >>

The NIA-JICA Diversified Crops Irrigation Engineering Project: Background, Objectives and Concerns

Serafin Palteng and Masao Morikawa'

Abstract

The objective of rice-based irrigation systems is to increase the cropping intensity in their service area. However, actual cropping intensities are at levels generally lower than design targets due **to** water-related factors.

Expansion of the area that can be irrigated with the available streamflow is an inherent concern of NIA. One of the strategies envisioned is the large-scale cultivation of low-water-requiring non-rice crops. Target areas are irrigationdeprived areas and parts of usually rice-cultivated command areas of irrigation systems during the dry season.

However, the technology for the irrigation of mixed-crop and bi-modal cropping patterns is still under-developed. Thus, the National Irrigation Administration (NIA) had launched the Diversified **Crops** Irrigation Engineering Project (DCIEP). DCIEP's role is to formulate **a** Diversified Crops Irrigation Engineering Manual through the compilation of existing information, conduct of supplemental research work and field surveys, and the development of component specialized schemes.

DCIEP is technically and financially assisted by the Japan International Cooperation Agency (JICA). Project implementation started in May 1987and is targeted for completion in May 1992. Field tests are being carried out in **a** 3-hectare trial farm located in San Rafael, Bulacan.

A special component of the Project is the construction, in 1989, of **a** DCIE Center which will consist of a training complex and **a** fully equipped soils laboratory.

The Project and the Center are supportive of the crop diversification program of the government.

Background and Objectives

Background. A 15-month study on ***Food Demand and Supply and Related Strategies for Developing Member Countries: Phase I*** jointly conducted by the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute **(IRRI)** with technical assistance from the Asian Development Bank (ADB) was concluded in May 1984. This study supported the production of non-rice seasonal crops in existing rice-based irrigation service areas in the country during the dry season to augment future food requirements. Realizing the importance of the recommendation, the Philippine government emphasized the production of diversified crops while striving to expand its current rice production capability and output.

The resulting agricultural diversification program has been perceived to be adaptable in the country. Since the country is composed of relatively small islands, its streams do not have large catchment areas. It is thus, difficult for an irrigation project to have **a** large benefitted area corresponding to inherently large construction costs. Under such conditions, cultivation of low-water-requiring crops, particularly during the dry season in irrigation service areas, is very important. Aside from meeting local food consumption, **a** foreseen benefit from the program is an increase in cropping intensity in irrigation service areas resulting in the following:

a) **An** expansion in irrigation-benefitted areas which is supportive of NIA's thrust to attain and maintain financial viability in

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the operation and maintenance of irrigation systems;

b) An increase in farm profitability and consequently the improvement of the living conditions of households within the irrigation service areas; and

c) A reduction, if not complete cessation, of dollar drain on account of feed raw materials importation and a likely reversal **of** dollar inflow from exportation of produce.

Considering these reasons, NIA proposed the ***Diversified Crops Irrigation Engineering Project*** (DCIEP) to the Government of the Philippines (GOP). Realizing the need to develop irrigation technology for crop diversification, the GOP requested for technical and financial assistance from the Government of Japan in May **1984.** The request was favorably considered and the project was placed under the JICA Project-type Technical Cooperation Program. The Record of Discussions (R/D) between the Japanese Implementation Survey and NIA was signed on **28** May **1987** - the date when the Project formally commenced.

Objectives. Until recently, virtually all irrigation systems in the country were designed for rice production. A recent study indicates, however, that **38%** of the designed 596,000-hectare aggregate area-isolate of 136 national irrigation systems are not sufficiently irrigated during the dry season. This situation is attributed mainly to low water flow available in the irrigation-tapped streams due to small watershed areas, denuded watersheds and inadequate rainfall.

Cultivation of irrigationdeprived areas to low-water-requiring crops with high market values is being considered. Intensive and extensive production **of** diversified crops under irrigated conditions is still a novelty to irrigation systems in the country. Domestic and basic technology is still under-developed. **It** was in this context that the Philippine Government based its request and the Project evolved.

In general, the Project aims to develop an irrigation engineering technology for diversified cropping under local conditions to promote diversified crop production and accelerate agricul-rural development programs in the country. Specifically, the Project aims to:

1. Study the most appropriate methods of providing irrigation to diversified cropping;
2. Establish technology criteria and standards for planning and designing irrigation and drainage facilities **for** non-rice crops; and
3. Conduct technical training for **NIA** technical staff, and an information campaign for the introduction of diversified cropping.

Implementation Schemes

Cooperation and General Strategy. The Project is a joint undertaking of the Government of the Philippines and the Government of Japan.

The responsibilities of the Government of the Philippines are the following:

1) Creation of composite Project implementing committee;
2) Appointment of full-time Project Manager and staff;
3) Assignment of counterparts **for** expatriate experts;
4) Provision of office space and facilities; and
5) Provision of transportation facilities for Project use.

The Government of Japan, on the other hand, shall contribute the following:

1) Dispatch long- and short-term experts to the Project;
2) Provide equipment and machinery; and
3) Accept NIA technical staff for training in Japan.

The general strategy laid out and observed for the attainment of Project objectives is composed of the following:

1) Investigation, collection and, if necessary, analysis of existing relevant materials and literature;
2) Conduct of field studies on the establishment of appropriate irrigation methods for diversified cropping;
3) Preparation of technology criteria and standards for the planning and design of irrigation systems for diversified cropping;
4) Training of concerned technical staff of the Project and of the implementing agency (NIA); and
5) Conduct **of** insight-gathering surveys in related research centers and premier irrigation systems.

Formulation of the targeted ***Diversified Crops Irrigation Engineering Manual*** of the Project is governed by the following principles:

1) Adoption with supplementation of the existing irrigation engineering technology in the country;

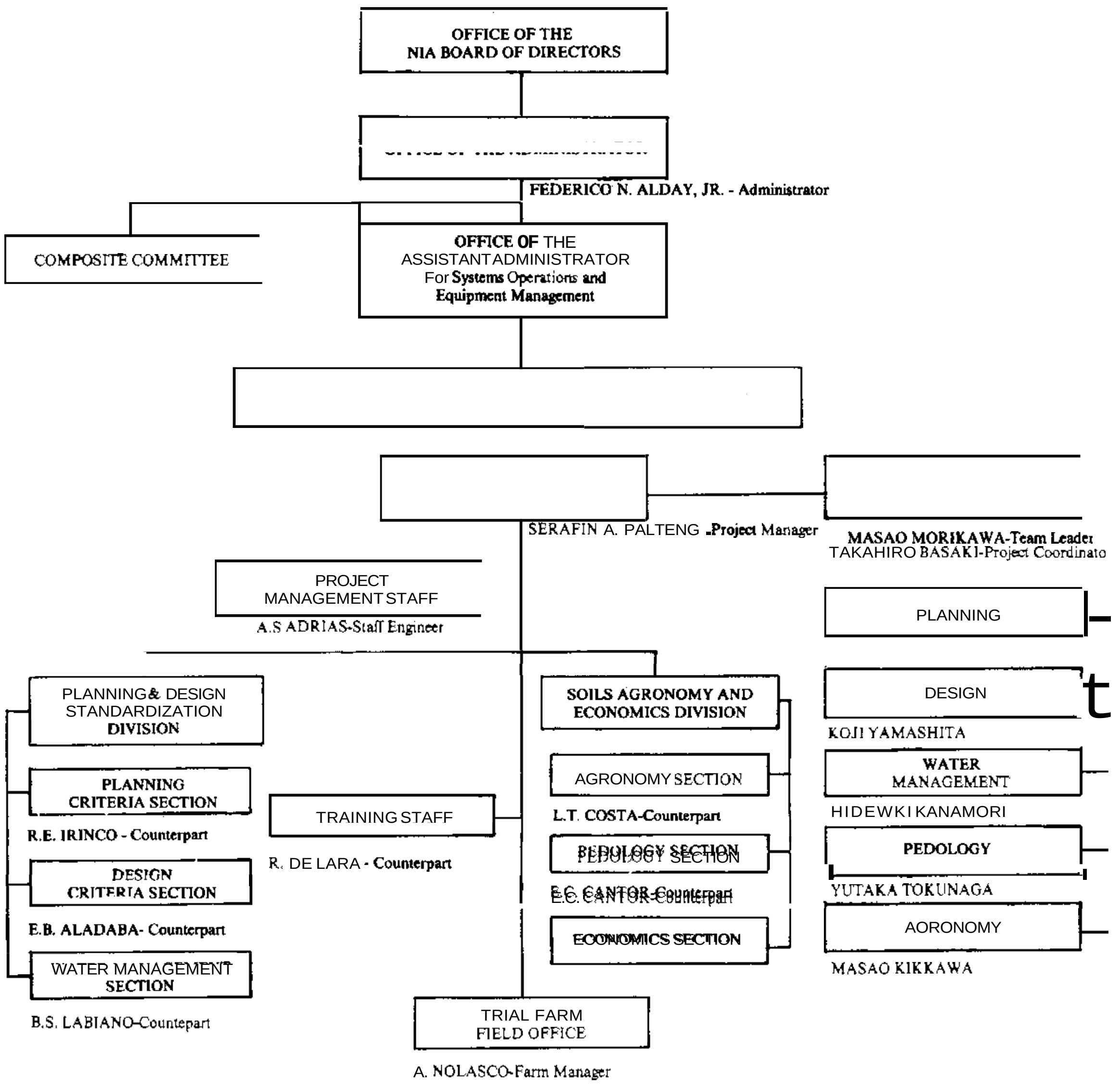
2) Development of new supplemental irrigation engineering technology, if needed;

3) Systematic compilation of data and information generated in the course of Project implementation; and

4) Contents of the design package to be prepared by the Project shall deal only on the sizing of irrigation facilities.

Organizational Set-up and Facilities. The Project is under the Office of the Assistant Administrator for Systems Operation and Equipment Management (SOEM) where a Composite Committee created under the Office of the Administrator develops policies. Under a detached set-up, the Project Office is composed of two divisions with three regular sections and two special units - Project Management Staff and Trial Farm Staff. Each regular section is assigned with an Expatriate Expert with an overall Team Coordinator and Team Leader (Figure 1).

Figure I- Organizational set-up, NIA-DCIEP



The main office of the Project is located at the NIA Headquarters in Quezon City. Field tests are being conducted at the Project's 3-hectare Trial Farm located in San Rafael, Bulacan where a newly renovated Field Office is also located. Close to the trial farm is the NIA Training Center which will be used by the Project for its future training programs. For soil and water analyses, the NIA Laboratory at Muiioz, Nueva Ecija (a 2-hour trip away from the trail farm) will be utilized.

Study Areas

The Project's Master Job Plan (MJP) and Tentative Schedule of Implementation **(TSI)** show four job items, namely, collection and analysis, field study, technology (criteria) formulation, and training. The details of the first two items are:

Compilation and processing of existing information on:

- Nationwide agricultural situation
- Diversified crops suitability conditions
- General irrigation situation
- Irrigation system formulation criteria
- Nationwide hydro-meteorological observations
- Irrigation facility design principles
- Drainage facility design criteria
- System design assumptions
- Basic water requirements
- Terminal irrigation methods
- System management schemes
- System level operation schemes
- System maintenance schemes
- Nationwide soil classification
- Irrigated areas land classification
- Diversified crops' soil conditions
- Diversified crops' statistics
- Diversified crops' characteristics
- Cropping calendars and patterns
- Crop cultural management practices

Field studies and/or survey on:

- Socio-economic conditions
- Irrigation network patterns
- Irrigated cropping patterns
- Water supply and consumption
- Terminal irrigation methods
- Terminal irrigation facilities: kinds and criteria
- Irrigation methods (system level)
- Water requirements and irrigation interval
- Operation and management systems and components
- Soil physical and chemical characteristics
- Soil-water relationships
- Water requirement components
- Diversified crops' characteristics

The Project is in progress and has accomplished some of its objectives. Its target output, i.e., Diversified Crops Irrigation Engineering Manual, will be completed before the Project ends in May 1992.

Crop Diversification: Problems and Prospects in Partially Irrigated Rice-based Farming Systems

H.C. Gines, T.B. Moya, R. K. Pandey and V. R. Carangal[1]

Abstract

A multidisciplinary on-farm research project was implemented in the service area of a deepwell pump system at Barangay Bantug, Guimba, Nueva Ecija in Central Luzon, Philippines. The project aimed to study techniques necessary to grow irrigated upland crops in rotation with wet season rice and to test the viability of these techniques with respect to agronomic, water management and socio-economic constraints. Agro-ecosystems of the research site were analyzed for infrastructural, socio-economical and technological constraints to crop diversification and intensification.

Baseline survey revealed that farmers practice double rice cropping in the lower strata (*lungog*) and single rice in the upper strata (*turod*) landforms. The rice-rice pattern leads to undue pressure on water resources during the dry season. With the present water use efficiency (WUE) of 50%, the irrigation system can adequately irrigate only one-third of the programmed area for dry season (DS) rice.

Research results for three consecutive crop years have shown that, if all farmers switch to upland crops such as corn and mungbean during the DS, it would be possible to cultivate 75 and 100% of the service area at 50 and 80% WUE, respectively. Evaluation and integration of component technology for upland crops improved the cropping sequence, i.e., rice-corn-mungbean and increased farmers income over existing cropping patterns.

introduction

Partially irrigated systems consist primarily of areas irrigated by deep tubewell (DTW) pumps. These areas usually have insufficient water supply for dry season rice (DS) cultivation. Consequently rice is cultivated over less than the full command area of many of these systems during the DS. Many governments saw groundwater development as an attractive alternative to high cost multi-purpose reservoir systems because of its potential to spread the benefits of irrigation to a wider area. As a result, deep and shallow tubewell systems have substantially increased in Asian countries during the past two decades. In most countries, the government subsidized both capital investment and annual operating cost to encourage the use of irrigation pumps.

At present, approximately 200,000 hectares (I 5.2%) of the irrigable areas in the Philippines rely on pumped water (NIA, 1984). The development of pump irrigation reached its peak during the early 1970's when the Central Luzon Groundwater Irrigation Project of the National Irrigation Administration (NIA) was established. This project constructed DTW pumps and necessary conveyance systems in five provinces in Central Luzon, namely, Pangasinan, Tarlac, Nueva Ecija, Pampanga and Bulacan. These DTW pumps were programmed to irrigate two rice crops in one year.

With low energy cost at the time, feasibility studies showed the potential viability of these systems. However, with increased operations and maintenance costs of DTW pumps for rice in the last few years, irrigation service fees rose to 91,400-₱2,000/ha (Moya, 1981). Due to high operations cost of DTW, double rice cropping is uneconomical. Therefore, there is a need to diversify cropping patterns to reduce water use and increase economic returns. Replacing dry season rice with

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upland crops will enable water distribution to wider area hence increasing cropping intensity on fallow land.

The shift in cropping patterns needs to address two issues: (l) the synthesis cropping systems, making them economically viable and acceptable to farmers in order to maximize farm resources and (2) the organizational arrangement necessary to distribute water to more fields on a given schedule. Considering these issues, the International Rice Research Institute (IRRI) Cropping Systems Program, in cooperation with the NIA and the Department of Agriculture (DA), initiated an on-farm research project with the followingobjectives:

1. to determine constraints to increased cropping on partially irrigated land,
2. to design alternative cropping patterns and develop component technologies related to these cropping sequences, and
3. to evaluate the alternative cropping patterns under existing farm resources and farmer management skills.

Materials and Methods

The Research Sire. The study was conducted in Barangay Bantug, **4 km** southeast of Guimba, Nueva Ecija. It is within the service area of a DTW pump (P-27) under the management of an irrigators' association. Table I shows the socio-economic profile of the site.

Table ***1.*** Socio-economic characteristics of the Guimba Cropping System Site, Bantug, Guimba, Nueva Ecija, Philippines, **1984.**

Mean farm size (ha)	I.7
Mean educational attainment of operators (years)	8
Mean age of operators (years)	39
Mean family sire	6
Family labor availability (man-days/month)	38
Multiple cropping index	**1.4**
Tenure (%):	
Own	***41***
Rent	**39**
Share crop	***6***
Amortizing	**8**

Guimba's climate is characterized by a 4-month wet period and a 6-month dry period. Transition between dry and wet season generally lasts for two months (May-June), and between wet and dry season also for two months (October-November). Solar radiation, air temperature and wind run characteristics at the site are shown in Figure 1.

Farmers at the research site classify land either as ***turod***, slightly elevated fields with light textured and easily drained soil or **as *lungog,*** lower fields with heavy textured soil where water accumulates early during the wet season (WS) and remains longer during the DS. Major difference in surface soil properties of the two landforms are summarized in Table 2. In this site, water losses during DS rice cultivation are high specially on the ***turod.*** Thus, high seepage and percolation (S&P) losses result in marginal production for rice cultivation during the DS but highly favorable for upland crops.

On-Farm Research Methodology

The methods developed **by** Zandstra **et** al., (I 981) for on-farm research were used in this study. The study was classified into four classes:

Socio-economicsurvey. Socio-economic data were obtained by first conducting a survey of all farmers in Barangay Bantug at the start of the project. Activities, input use, and outputs of sample farmer-cooperators were monitored.

Farmer-manoged croppingpattern (CP) trials. All operations and management decisions, from land preparation to harvesting, were performed by farmers in consultation with the site staff. The project provided all farm inputs for the trials except for irrigation fees which the farmer-cooperators paid. The cropping pattern field size was 1000 m^2. Crop cuts were taken from CP fields; farm produce were returned to the farmers after the necessary data were obtained.

Twelve farmer-cooperators were selected from each landform to test designed CPs. CP test fields were grouped together in sets of four to facilitate distribution and measurement of irrigation water. Regular field visits were scheduled to obtain reliable information on field operations.

Superimposed trials. The superimposed trials were designed to evaluate the response of crops to

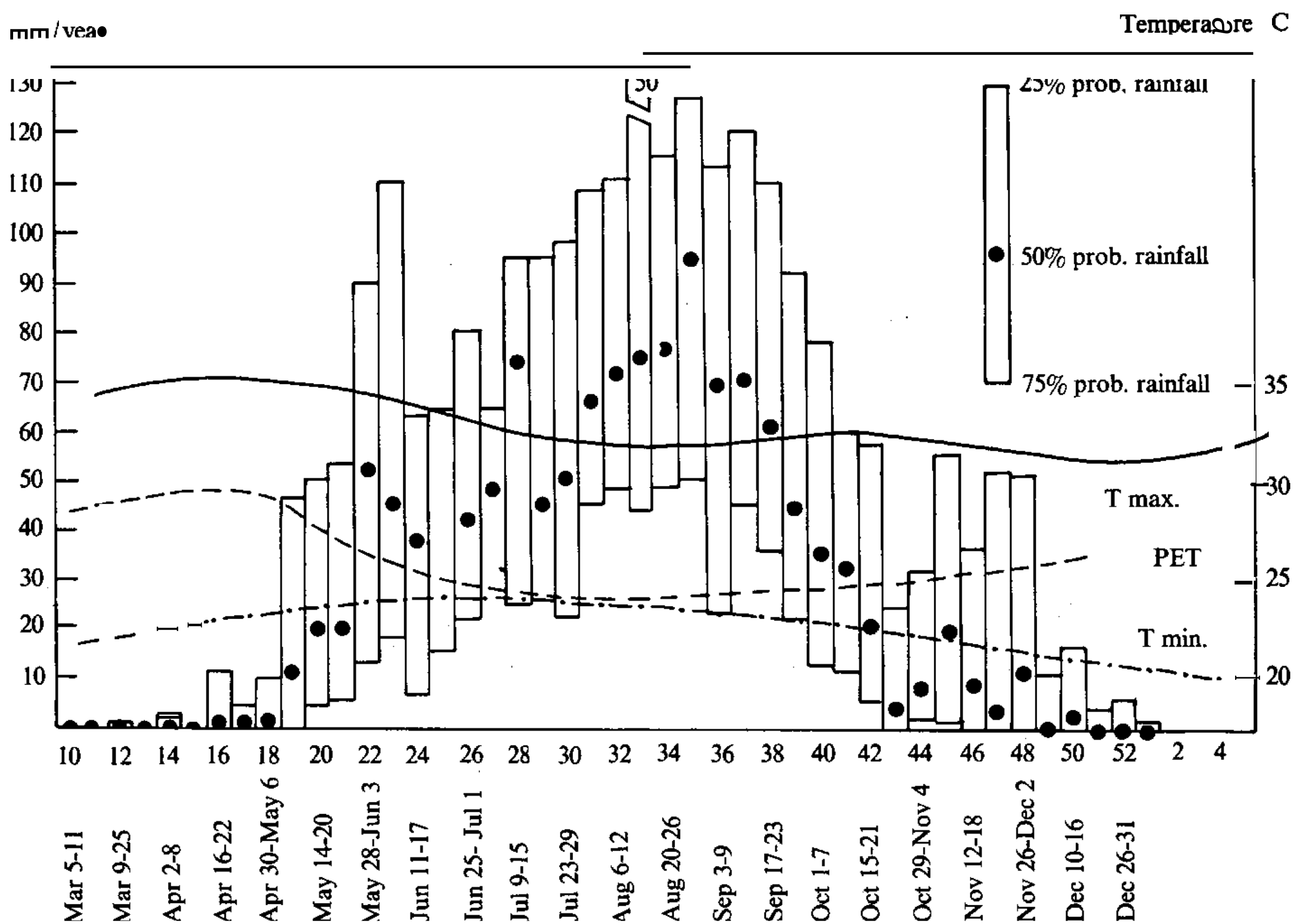

Figure 1. Upper quartile (75%), median (50%) and lower quartile (25%) rainfal probabilities, potential evapotranspiration (PET) and maximum and minimum temperatures (Tmax and Tmin) by weeks, for Cabanatuan, Nueva Ecija, Philippines.

Table 2. Soil characteristics in two landforms, means of four composite samples from three fields in Guimba.

	Landform	
	Turod	Lungog
Textural class[a]	Loam	Clay loam
pH (1:1 water)	6.7	7.1
Organic matter (%)	2.3	5.5
Available P (Olsen, ppm)	11	16
Available K (Cold H_2SO_4 ppm)	57	35

[a]Soil analyzed at NIA Laboratory, Central Luzon State University, Nueva Ecija, Philippines.

fertilizer application in a range of field conditions on farmer's cropping pattern fields.

Water data management. Irrigation rates supplied to each experimental farm were measured by using either a cutthroat or a Parshall flume installed at a strategic point before each substratum. Duration of irrigation application was computed from the records of the gatekeeper. Based on the flow rates and duration, the total amount of irrigation water applied was computed. Daily rainfall was monitored using a plastic rain-gauge placed near the pump site. The sum of the amount of rainfall and irrigation water applied represents the available water supply.

A sloping gauge, installed at a representative location on each farm, measured the daily rate of S&P. Evapotranspiration (ET) wasestimated using a class A open pan. The amount of water the irrigation system must deliver on time to avoid water stress was obtained by summing S&P and ET.

Technical Basis for Design of Cropping Pattern

Before alternative CPs were designed, data pertaining to the physical environment and demographic characteristics were collected from secondary sources. For market information, individuals involved in agribusiness were interviewed. Information on farm resources, current production practices and production levels were obtained by interviewing farmers.

Designed Cropping Sequence and Crop Culture

Existing and alternative cropping patterns are shown in Figure 2. Management practices for component crops designed for ***turod*** are presented in Table 3.

Agro-economic Evaluation

Data from CP fields were used to evaluate agronomic and economic performance. The economic analysis combined seasonal wage rates. The marginal henefit-cost ratio was used to test the profitability of designed cropping patterns.

RESULTS AND DISCUSSION

A crop year was divided into three seasons, i.e., WS (June to October), transition season (November to December) and late DS (January to May).

Agronomic Performance

Grain yield data for all component crops in CP trials for three consecutive crop years (1984 to 1987) are presented in Table 4.

Component Crop I - WS rice on turod and lungog. Grain yields in 1985 and 1986 averaged 4.5 and 5.0 t/ha, respectively, higher by 0.5 and 1.0 t/ha than in 1984. In 1985 and 1986, rice varieties IR56, IR58 and IR64, were grown in both landforms. These varieties were not affected by rice tungro virus (RTV). In 1984, RTV reduced grain yields of IR36 and IR42. Attack of stem borer and other insect pests were also lesser in 1985 and 1986 compared to 1984.

Component technology research in WS rice. Studies on fertilizer application in both landforms showed no evidence of phosphorus (P) and potassium (K) deficiency. Application of zinc did not

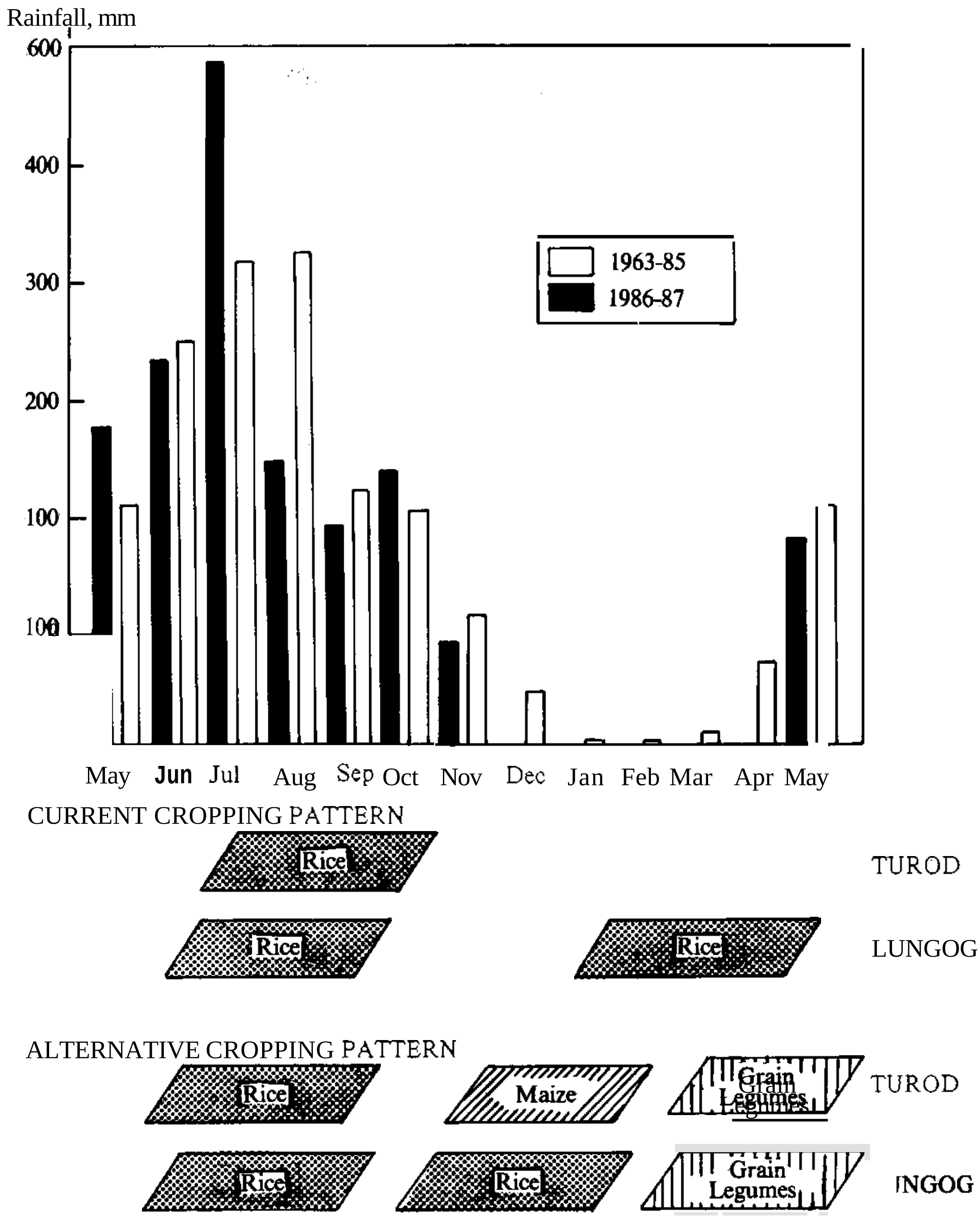

Figure 2. Mean monthly rainfall, current and alternative cropping patterns for partially irrigated land in Nueva Ecija Cropping Systems Research Site. Lungog land is lower lying than Turod and therefore easier to irrigate for rice in the early DS.

Table 3. Cultural nractices for crops included in the cropping pattern being tested on the *turod* landform.

Cultural Practices	First Crop Transplanted Rice	Maize	Munghean
Variety	IR42 (115 d FD)	Hybrid SMC-305	Pagasa (85 d FD)
Establishment period	10-30 June	1-20 Nov	15 Feb - 5 Mar
Hill/row spacing	20 X 20 cm	75 cm bet. rows	46 cm bet. rows
Seedling/hill or plant density	2-3 plants/ hill	50-60, '000 pph	225-250, '000 pph
Fertilizer (N-P_2O_5-K_2O) (kg/ha)	70-30-0 + Zn	None	None
Tillage	Plow and puddle	Plow and harrow	Zero tillage (RIP)
Weed control	Thorough land preparation fb butachlor 0.6/8 ai/ha; 3-4 DAT		None
Insect control	Economic threshold	lnterrow cultivation. Detassel and Furadan	4 sprays
Disease control	None	None	None
Irrigation strategy	Monitor rainfall suspend pumping when not needed	4 times	2 times

Table *4.* Crop yields (kg/ha) in rice-corn-mungbean and rice-rice-mungbean cropping patterns for three crop years under partially irrigated environment, Guimba Cropping System Outreach.

Cropping Pattern	Crop Year 1984/85	1985/86	1986/87
	Turod		
I Rice	3.97"	4.70'	**5.02**[d]
2 Maize	2.59[f]	4.45'	4.489
3 Mungbean[h]	0.91	1.10	1.07
	Lungog		
I Rice	4.03'	4.26'	4.90[d]
2 Rice	**1.91**[e]		
3 Mungbean			

"Average yield of IR42, IR54, IR56
[b]Average yield of IR36, IR54, IR56
'Average yield of IR56, IR58
[d]Average yield of IR64
'Average yield of IR36
'Corn hybrid used – SMC 305
'Average yield of SMC 305 and IPB varieties
[h]Mungbean variety -- Pagasa I
Note: In the *lungog,* establishment of the second rice crop was suspended in crop year 1985/86 in CP fields. Mungbean was not planted due to waterlogging.

consistently show yield advantage. Response to nitrogen (N), however, was significant in both landforms. Partial budgeting was used to determine the most profitable level of fertilizer application in RM **1985 WS** rice experiment in ***lungog.*** Maximum yield was at **64-13-24** kg NPK/ha, but net benefit/ha was highest at the rate of 60-0-0. A comparison of ammonium sulfate and urea N in *lungog* showed that efficiency was not significantly different.

Component crop 2 - ***corn*** *on turod.* Mean yield of corn in **1984** was only **2.59** t/ha, much lower than the potential yield of the corn hybrid used. Crop establishment was a major bottleneck. In many fields, large clods that formed during primary tillage were not reduced in size even after secondary tillage resulting in poor soil-seed contact and low emergence. Other obstacles included drought in fields far from the pump and waterlogging in fields close to ditches or adjacent to flooded rice fields.

In **1985** and 1986, fields were sufficiently dried and was irrigated by flushing before primary tillage was performed. This *method* resulted in a relatively good soil tilth and improved crop stand. Yields increased by almost **50%** in **1985** and **1986** Although the mean yield in **1986** was **4.48** t/ha, highest yields obtained in one CP field was 7 t/ha.

Component technology research in corn. Fertilizer studies in corn showed positive response to N fertilizer, although response varied across fields. The highest mean yield in **1985** was **3.5** t/ha. Nitrogen fertilizer efficiency averaged **28** kg grain/kg N.

To increase corn yield with improved cultural practices in 1986, a field study was conducted to evaluate the effect of frequency of irrigation and N rate on performance of hybrid corn (Table **5).**

Increasing water application from three to five times significantly improved grain yield. The increase in grain yield was brought by improvement in yield components. Application of 120 kg N/ha resulted in higher yield compared to **80** kg N/ha. The interaction of irrigation and N rate was significant. NPK uptake increased with higher irrigation frequency and was positively correlated with increase grain yield (Figure **3).**

Component Crop* 2 - *transition rice *on* ***lungog.*** Low solar radiation, lower night temperatures and strong winds from the northeast deterred the growth of rice during the transition season (TS). Mean yield of rice planted in late October **1984** was **1.91** t/ha. To improve rice yield, a field experiment was conducted with **six** transplanting dates at 3-week intervals from **30** October **1985** to 12 February **1986.** The **30** October planting yielded the lowest while the **22** January planting yielded the highest (Table **6).** Panicle exertion was reduced in the early planting dates (30 October to 11 December), with a mean panicle exertion of **74%** compared to a mean of **97%** in later planting dates.

Cool night temperature was associated with lower panicle initiation. The decrease in yield in the 12 February planting was a result of water stress

Table 5. Grain yield and yield components **as** influenced by the different rates of **N** and frequency **of** irrigation.

Number of Irrigation	Grain yields **(kg/ha)**	100-Grain weight (g)	Available Ear length (cm)	Available Diameter **(cm)**	Stem length (cm)
			N80-P30-K30 kg/ha		
3	**3648**	**20.6**	**10.1**	**4.2**	. **155.6**
4	**4666**	**22.1**	11.1	**4.3**	**158.2**
5	**5004**	**23.5**	**11.5**	**4.3**	**161.3**
			N120-P30-K30 kg/ha		
3	**5891**	**24.5**	**12.6**	**4.5**	**159.4**
4	**5983**	**23.9**	**13.2**	**4.5**	**153.9**
5	**6888**	**25.2**	**14.0**	**4.5**	**159.2**
CV	**7.8**	**5.7**	**5.0**	**2.3**	**3.4**
LSD (.05)	**6.31**		**0.9**	0.15	**ns**

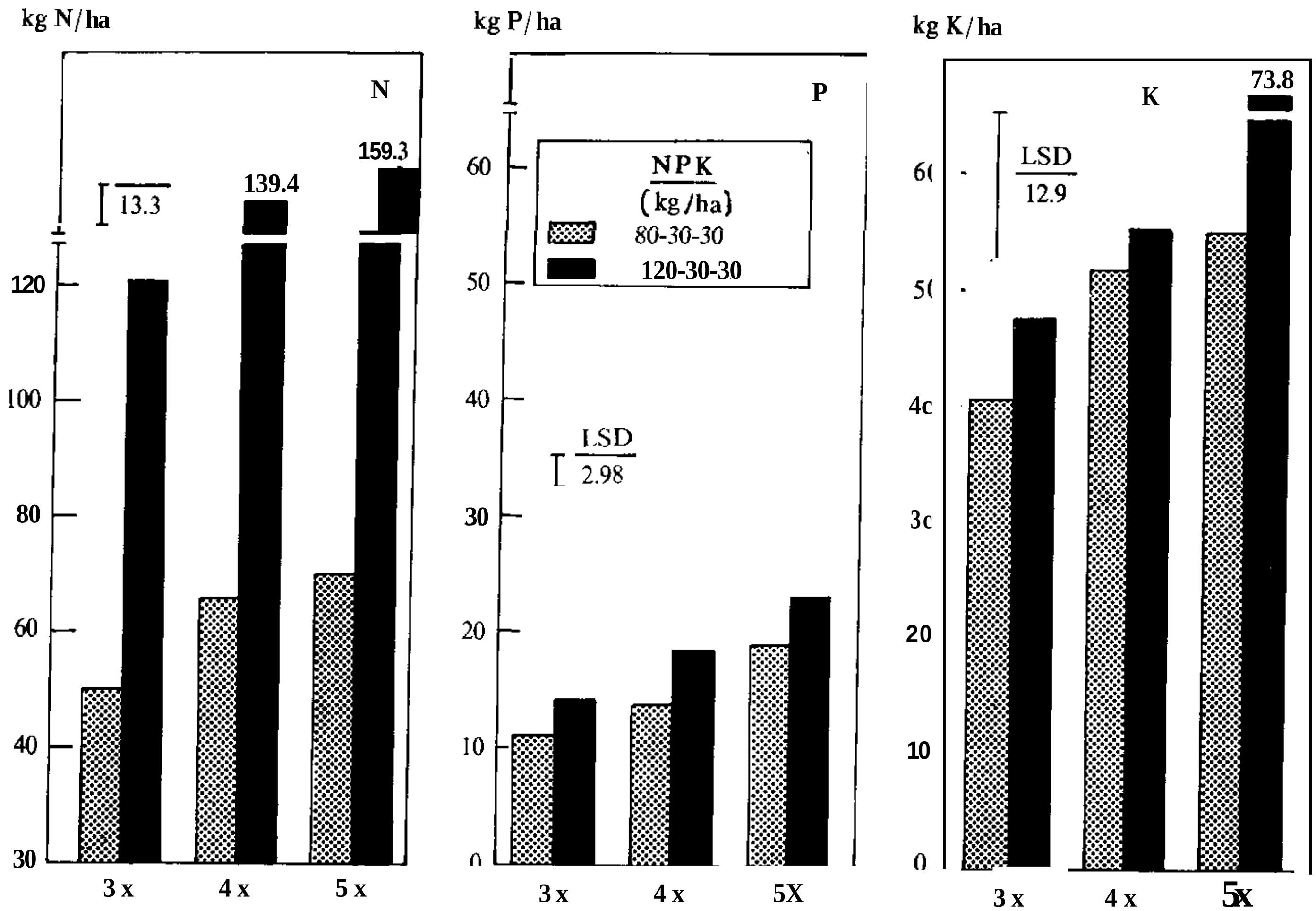

Figure 3. Total N, P, nd K. Uptake of corn as influenced by N rate and irrigation frequency.

Table 6. Yield and yield components of IR58 as affected by dates of transplanting, Guimba, Nueva Ecija, crop year 1985/86.

Date of transplanting	Yield	Plant height	TDMY	Productive tillers	Panicle exertion
30 Oct 1985	2.38 e	52.8 c	3.36 c	16 c	73 c
20 Nov 1985	3.34 cd	51.3 c	5.71 b	17 c	73 c
11 Dec 1985	3.04 d	55.2 bc	4.62 c	22 ab	75 c
I Jan 1986	3.82 h	55.0 bc	6.04 a	24a	91 b
22 Jan 1986	4.31 a	64.0 a	5.49 b	20 b	99 ab
12 Feb 1986	3.50 bc	59.3 b	5.59 b	22 ab	100 a
Diff. bet. treatment means	hs	hs	hs	s	hs
CV (%)	5.97	3.59	11.43	7.93	3.32

Means having a common letter are not significantly different at the 5% level of significance.

due to lack of timely irrigation. The relationships between planting date, weather data and field duration of IR58 at different dates are given in Figure 4. The highest yield was obtained when crop duration fell between January and April. During this period, the crop was exposed to favorable solar radiation and temperature with a low wind speed. A wind barrier study was conducted in 1987 to evaluate the performance of IR64. The study compared the performance of fully and partially protected and totally unprotected crops. A wind barrier made of plastic was constructed at three sides of the fully protected crops perpendicular to the wind flow. Results indicated that fully protected crops obtained significantly higher grain yield, taller plants and more filled grains than either the partially or totally unprotected plants.

Component Crop 3 - Late DS mungbean on both landforms. Mungbean on turod adapted well to the post-corn DS period. Mungbean yields were 0.91 t/ha in 1984 and at least 1.0 t/ha in 1985 and 1986. There were no production constraints encountered in mungbean. Grain quality of late planted mungbean was affected by the early rains in May. Delayed transplanting of rice on lungog left Little time to establish mungbean before the WS rain started. Therefore, mungbean was not planted on lungog.

Management of Water in the Service *Area*

Increase in electrical power costs had jeopardized the economic viability of deep tubewell irrigation systems. High energy cost resulted to the current irrigation service fees of 450 kg of paddy/ ha during the WS and 800 kg/ha during the DS. Because of high irrigation fees, many farmers within the P-27 service area decided not to avail of the pump's services.

Wet season water management. During the 1984 WS, all farmers in the P-27 service area planted rice. Rainfall provided most of the crop water requirements. The pump was used only when rainfall was inadequate (Figure *5).* Data from six sample farms, three in *lungog* and three in turod areas, indicate high variability in S&P rates within the service area (Table 7). The average water requirement during the WS was 518 mm for land preparation and 694 mm for crop growth. Average water actually supplied was 446 mm for land preparation, of which 344 mm was rainfall and 102 mm was water supplied from the pump for three weeks in July, when rainfall averaged less than 60 mm/week. The water deficit of 72 mm during WS land preparation can be attributed to farmers' reluctance to use the pump, thereby reducing the energy bill. Many farmers opted to wait for more rain as was the case in many *lungog* fields. This was a major factor in delaying the bulk of transplanting

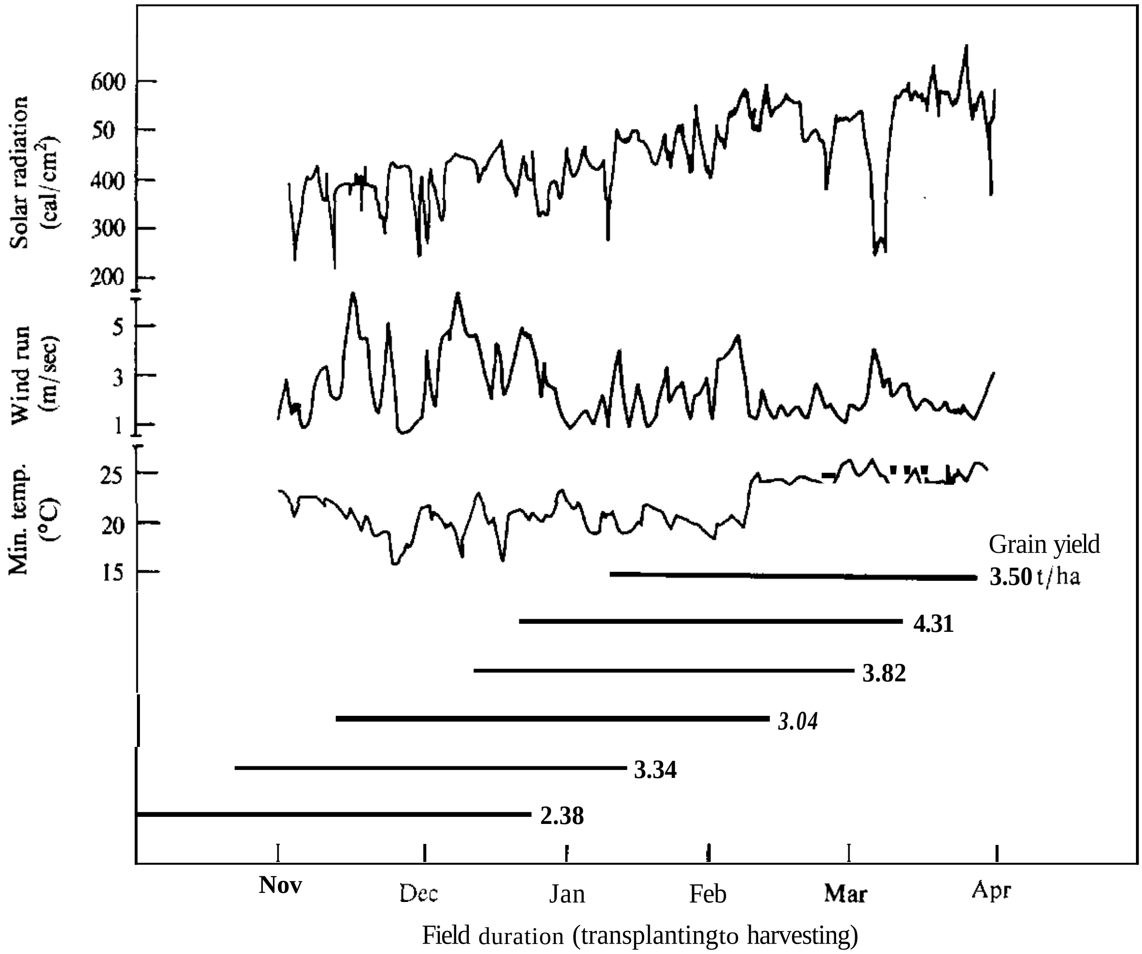

Figure 4. Field durations of IR58 as affected by temperature, wind velocity and solar radiation Guimba Diversified Cropping Systems Project. CY 1985-1986.

until August. The reluctance to use pumped water resulted in 110 days between initial plowing and final transplanting, about twice that of comparable systems in Tarlac and Bulacan.

Water use for the WS crop growth period averaged 896 mm, most of which was rainfall. Irrigations were applied only twice during the growth period to supplement rainfall, once in early August and the other in late September. In both irrigations, however, the amount of water applied exceeded the deficit, leading to lower-than-desired water use efficiencies.

During the WS as a whole, water use efficiency when the pump was operated was low. Since each farmer is able to request water on an individual basis, channels must be filled up before water can flow onto his field. When irrigation stops, much water remains in the channel as dead storage losses. In addition to losses in the main channel system, measured at 28% loss over a 325 meter section of the lined main channel, average farm level water use efficiency was only 45% during the WS. indicating that farmers generally used more than twice as much water as needed to satisfy crop water requirements. The average water productivity, 0.22 kg of rice/m^3 of water during the WS (Table 8), was comparable to gravity systems where irrigation fees are only 100 kg paddy/ha.

Dry season water management. Water management activities during the 1985 DS were closely monitored because these are the most critical activities in terms of cost saving. Pump discharge records showed a much greater decline in discharge during the DS than was expected (Figure 6). Pump

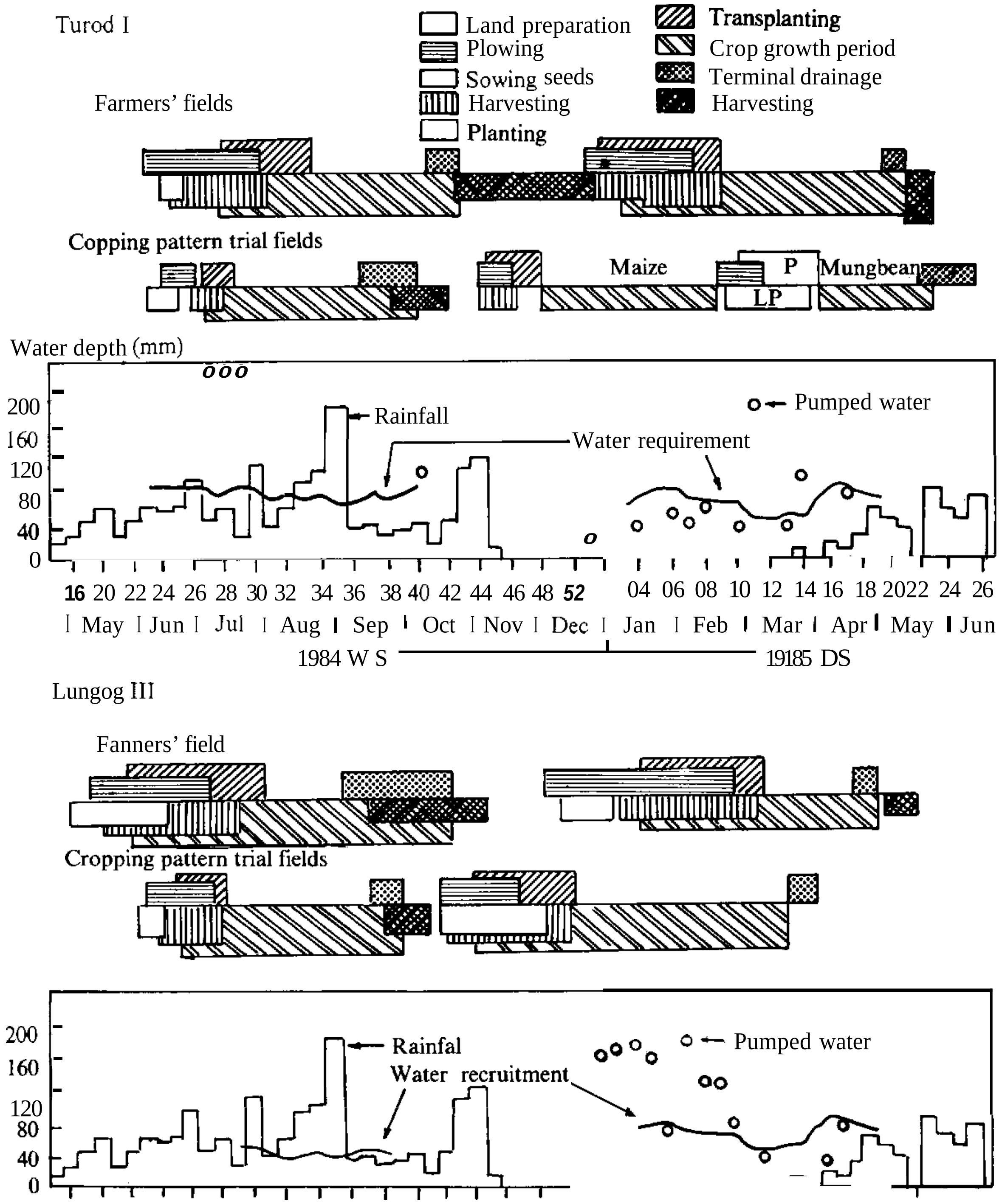

Figure 5. Cropping pattern and crop activity schedules in farmer's and experimental cropping patterns, weekly rainfall, pumped water, and crop water requirements. Guimba, Nueva Ecija, Philippines, 1984 WS and 1985 DS.

Table 7. Water requirements for rice and water supplied to Farmers' fields for land preparation and crop growth, **P-27,** Guimba, Nueva Ecija, **1984** WS and **1985** DS.

Land strata	**1984** wet season		**1985** dry season	
	Water Requirement (mm)	Water Supplied (mm)	Water Requirement (mm)	Water Supplied (mm)
	Land Preparation			
Lungog	492	331	408	320
Lungog I	324	370	369	316
Lungog II	363	479	352	394
Lungog III	739	143	527	250
Turod	557	561	368	402
Turod I	557	483	356	241
Turod II	31 I	532		
Turod III	816	669	380	564
P-27 Service Areo	518	446	397	353
	Crop Growth			
Lungog	628	853	761	1041
Lungog I	659	940	860	1223
Lungog II	733	865	607	500
Lungog III	494	755	817	580
Turod	759	939	1036	583
Turod I	956	879	1171	471
Turod II	737	1078		
Turod III	584	859	901	695
P-27 Service Area	694	896	871	694

"Farmers at Turod II did not plant rice

discharge remained static at 112 liters per second **(Ips)** throughout the WS. However, in mid-December, pump discharge steadily declined to *56* **Ips** until mid-March and remained at this level until the end of the DS. At thisdischarge level, water use efficiency must be high to irrigate sufficient land to make energy costs reasonable since water requirements are considerably higher during the DS.

Average water requirements were 397 mm for land preparation and 871 mm for crop growth (Table **7).** The low value for land preparation was attributed to residual moisture from the WS crop while increased value for crop growth **was** due to higher evapotranspiration during the latter part of the DS.

During the DS, virtually all crop water needs must be met by pumping. During land preparation, average water deliveries were almost adequate to meet requirements: deliveries of 353 mm were made compared to a requirement of 397 mm. However ***lungog*** areas received **116%** of the requirement while ***rurod*** areas received only **70%.**

During rice crop growth period, water supply became increasingly constrained. In the initial stages, relative water supply (RWS) was almost always greater than 1.0 indicating that supplies exceeded demand. ***Lungog*** areas were better off than *turod* areas, with RWS averaging **1.48** compared with 1.15 (Table **9).** However, **as** the **DS** progressed, evapotranspiration increased and pump discharge declined, resulting in adecrease in RWS in **all** areas. Drought stress was widespread. Lungogareas had RWS values of 0.91 while RWS fell to **0.73** in rurod areas. Breakdown of the pump in April intensified the stress that had developed.

Yields were higher during the DS than during the WS because of higher solar radia 'on.

Because rainfall was negligible, there **was** higher productive value of water during the DS. In *lungog* and *turod* areas, about **0.42**kg **of** rice/m^3 **of**

Table 8. Mean crop-cut yield and water productivity in farmers' fields, **P-27,** Guimba, Nueva Ecija, **1984** WS and **1985 DS.**

Land strata	1984 wet season		1985 dry season	
	Yield (kg/ha)	Water productivity (kg/m^3)	Yield (kg/ha)	Water productivity (kg/m^3)
Lungog	**3488**	**0.25**	**4150**	**0.40**
Lungog I	**3666**	0.26	**4265**	**0.30**
Lungog **II**	**3063**	**0.21**	**3961**	**0.44**
Lungog III	**3736**	**0.28**	**4225**	0.51
Turod	**2713**	**0.17**	**3809**	**0.39**
Turod **I**	**2874**	**0.21**	**3803**	**0.53**
Turod **II**	**2009**	0.12		
Turod **III**	**3251**	**0.22**	**3815**	**0.30**
P-27 Service Area	**3100**	**0.22**	**4014**	**0.42**

[a] Farmers at Turod II did not plant rice.

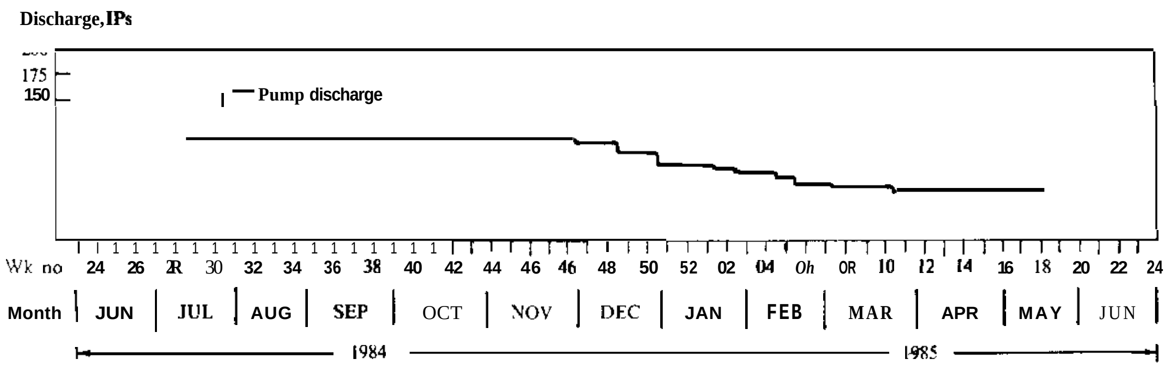

Figure 6. Pump discharge from P-27, Guimba, Nueva Ecija, 1984 WS and 1985 **DS.**

water was obtained, indicating that the system was more 'efficient than gravity irrigation systems but still well below what could he achieved. In experiments conducted in one ***turod*** farm planted to corn, the productive value of water was 1.18 kg of corn/m^3 of water. However, the price of rice exceeds that of corn by about **2.5** times, meaning that in monetary terms, the productive value of water was almost the same for the two crops.

Despite the scarcity of water during the DS, it was not used efficiently. Farm level water use efficiencies averaged only 48%, indicating that farmers applied twice as much water as required. Main system efficiencies were also similar to WS levels, despite efforts to cement cracks in the lining. Following repairs to the channel, losses decreased from ***28*** to ***25%*** over the ***325*** meter section. Overall efficiency of the system was less than 35%, well below the acceptable level.

Improving water use. If pumping costs of P-***21*** are to be reduced, attention must be given to coordination **of** field operation, on-farm water use efficiency and coordination in water deliveries.

1. ***Timing of operations.*** The current cropping calenaar leads to undue pressure on water resources during the DS. Because discharge from the pump is lowest in March, a late start of DS land preparation means that the period of highest crop water requirements coincides with lowest level of water availability This effectively limits the area that can be served. The irrigators' association (PAFIA) aims to irrigate ***35*** hectares during the DS. Using

Table 9. Mean weekly relative water supply[a] P-27, Guimba, Nueva Ecija, 1984 WS and 1985 DS

Land strata	1984 wet season		1985 dry season	
	Vegetative oeriod	Reproductive period	Vegetative period	Reproductive period
Lungog	1.61	1.44	I.48	0.91
Lungog I	1.42	1.50	I.67	1.46
Lungog II	1.37	1.63	1.66	0.74
Lungog III	2.04	1.20	1.10	0.52
Turod	1.46	1.12	1.15	0.73
Turod I	1.18	0.80	0.77	0.66
Turod II	I.42	1.28	b	
Turod III	1.77	1.27	1.53	0.80
P-27 Service Area	1.53	1.28	1.35	0.84

$$\text{RWS} = \frac{\text{Irrigation} + \text{Rainfall}}{\text{Water requirement}}$$

[b]Sample farmers at Turod II did not plant rice

measured values of field level water requirements and assuming zero rainfall, it is possible to determine what area can he irrigated at different levels of water use efficiency (WUE) if no crop stress is to occur, These calculations indicate that if the pump is operated for 12 hours/day (actual use during the 1985 DS was 12.8 hours/day) and if WUE is 100%, the latest planting date for a 35 hectare DS area is week 45 (Figure 7). If an 80% WUE is assumed, the latest planting date is at week 41 (early October). If WUE is lower than 65%, it is not possible to irrigate 35 hectares for rice during the DS. For an early DS planting, the WS crop must have been harvested, which in turn presumes that the WS crop is transplanted earlier than is currently the case.

The modal date of planting of farmers during the 1985 DS was week 7 (mid-February). If WUE is 80%, then it is possible to guarantee only 16 hectares of rice, given the declining pump discharge (Table 10). Current WUE of 35% can guarantee only 8 hectares of rice, indicating that crop stress is inevitable with larger areas cultivated. Operating the pump for periods longer than 12 hours/day would enable larger areas to he cultivated but does not reduce per hectare pumping costs. There is also a risk that longer pumping hours make crops more susceptible to widespread drought stress if the pump fails and cannot be repaired quickly.

An analysis of the pumping cost per hectare shows the same basic trend (Table 11). If rice is transplanted by mid-October, then with 12 hours/day of pumping and WUE of 80%, the cost to farmers would be ₱1,764/ha. Delaying planting to February increases the cost to ₱4200/ha provided other factors are kept constant. If planting is in February, then costs increases to ₱6,552/ha at 50% WUE and ₱9,513/ha at 35% WUE. The current DS irrigation fee is ₱2,898/ha, which can only be achieved by planting in October and operating the system at more than 50% WUE.

If farmers plant crops other than rice, then there is a potential for a large increase in the irrigated area and a consequent reduction in operating cost per hectare. If all farmers were to plant either corn or mungbean during the DS, then it is possible to cultivate the entire service area if planting is to be done early and WUE is 80% (Table 10). Pumping costs would range from P378 to ₱483/ha. At 50% WUE, it is possible to grow 52 hectares of corn or 63 hectares of mungbean, with pumping costs of only ₱819/ha and ₱630/ha, respectively. However, due to waterlogging in *lungog* areas, it is likely that rice will remain the preferred crop, at least during the TS and early DS. Thus, it is more advisable to grow upland crops in lighter *turod* soil and rice in *lungog* soil. This would permit 30 hectares for each crop to be cultivated if WUE is 80%, decreasing to 19 hectares each if WUE is 50%. However, it is essential to maintain an early start during the DS. Each day of delayed planting after mid-October requires an increase in WUE of approximately 1% or a reduction in area of 0.25 hectare to avoid crop stress.

2. *On-farm water use efficiency.* During the WS and DS, average water use efficiency at the

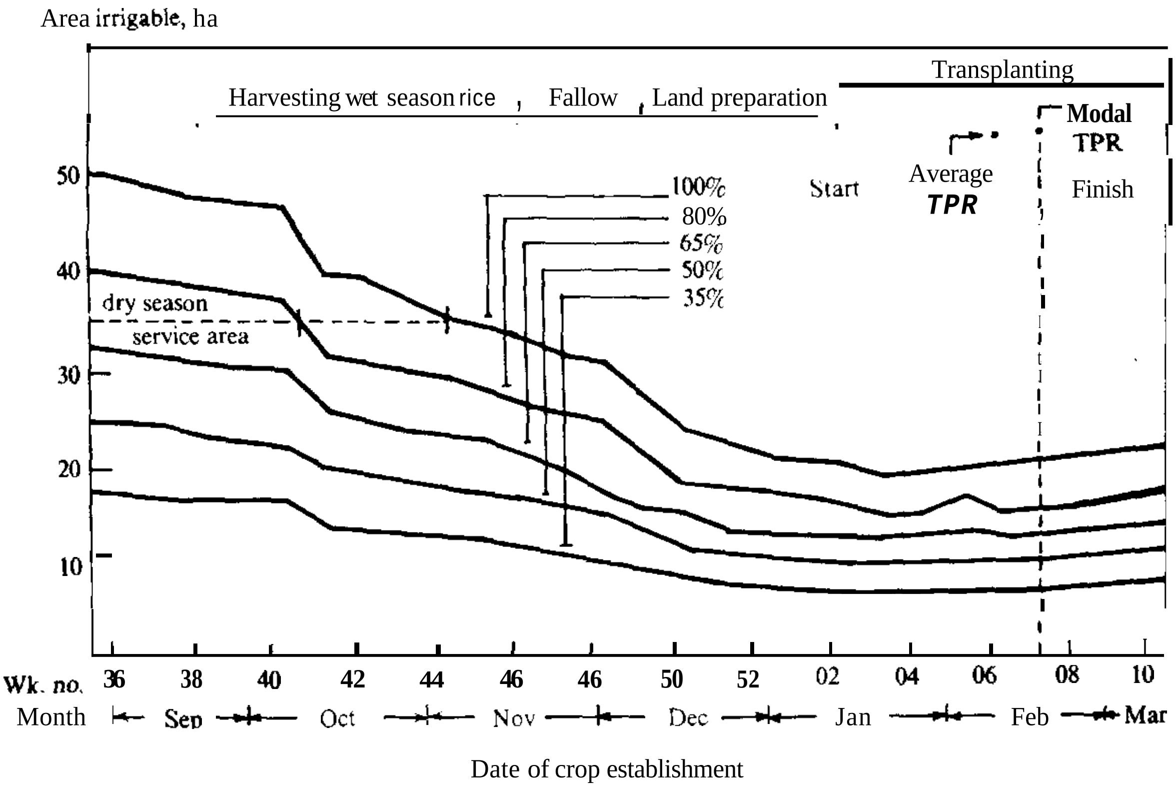

Figure 7. Irrigable areas for differrent crop establishment dates at 5 water use efficiency levels; assuming that P-27 operates 12 hours per day, Guimba, Nueva Ecija.

Table 10. Dry season irrigable areas (ha) under four WUE for three cropping patterns establishedat different periods, assuming that **P-27** operates for 12 hours daily, Guimba. Nueva Ecija.

Cropping patterns	Establishment period	Water Use Efficiency			
		80%	65%	S0%	35%
Pattern I: ***Rice-Rice***					
• ***Rice*** (lungog and turod)	**1-15 Oct**	**37.1**	**30.2**	**23.2**	**16.2**
	12-25 Feb	**15.6**	**12.8**	**10.0**	**6.9**
• ***Rice*** (iungog only)	**1-15** Oct	**40.2**	**32.6**	**25.1**	**17.6**
	12-25 Feb	**16.7**	**13.6**	**10.4**	**7.3**
• ***Rice*** (turod only)	**1-15** Oct	**34.5**	**28.0**	**21.6**	**15.1**
	12-25 Feb	**14.7**	**12.0**	**9.2**	**6.4**
Pattern 2					
Rice-rice (lungog)					
Upland crops (turod)	**1-15 Oct**[a]	**(41.3)**[b]	**(33.6)**	**(25.9)**	**(18.2)**
Pattern 3:					
Rice-Upland crops	**1-20** Nov				
• **corn**		**89.4**	**67.4**	**51.8**	**39.1**
• Mungbean		**100.4**	**81.6**	**62.7**	**43.4**

[a]Es ne period nly for ıd crops p e on 1 0 No emt
[b]Ef i area weighed at farmgate of ₱1.05/kg of corn and ₱3.50/kg of rice.

Table 11. Energy costs (₱/ha) for three cropping Patterns established at different periods, and WUE assuming that P-27 operates **for** 12 hours daily, Guimba, Nueva Ecija.

Cropping patterns	Establishment period	Water Use Efficiency			
		80%	65%	50%	35%
Pattern 1: ***Rice-Rice***					
• Rice (lungog and turod)	***1-15*** Oct	1764	2163	283.5	4053
	12-25 Feb	4200	5124	6552	9513
• Rice (lungog only)	1-15 Oct	1638	2016	2604	3738
	12-25 Feb	3927	4830	6300	8988
• Rice (turod only)	1-15 Oct	1911	2352	3045	4347
	12-25 Feb	4452	5460	7140	10248
Pattern 2: ***Rice-rice (lungog) Upland crops (turod)***	1-15 Oct[a]	1596	1953	2541	3612
Pattern *3:* ***Rice- Upland crops***	**1-20** Nov				
• Corn		483	630	819	1092
• Munghean		378	483	630	924

Note: Energy cost per hectare computed based on farmgate price of **₱12.60/kg** for corn, **₱3.57/kg** for rice and ₱11.55/kg for mungbean and electricity cost of **$1.89/kWhr**.
[a]Establishment period **only** for rice, upland crops planted on 1-20 November.

farm level ranged from 45 to 50%. Having decided to irrigate, farmers used water extravagantly.

3. ***Main system efficiency.*** Lesser improvement in the conveyance efficiency following repair of cracks in portions of the main system indicated that most losses were operational rather than structural in nature. It took a long time to **fill** the main channel before water can **flow** into the fields. Thus, serving isolated farms was found to be inefficient. Moreover, many farmers deliberately made access to the main channel, ***so*** that they benefited whenever farmers further down the channel receives water. At present, it is incumbent on the farmer requesting water to close upstream turnouts, most of which no longer have gates.

The Former-Irrigators' Association

Although many technical factors affect the efficiency of water use, there is still potential to increase **DS** crop production in the P-27 service area. Realization of the potential centers around farmers' ability to use a limiting resource (water in an aquifer) more efficientlv. To increase efficiency, the management of the P-27 system must improve. P-27 is managed by an irrigators' association.

The organization, power structure and functions of the P-27 irrigators' association were examined. Collection of the seasonal irrigation fee is an important function of the association. Costs and farmers' perceptions on the benefit from paying the fee affect farmers' decision to pay.

Assessing Economic Viability of Improved CPs

Economic returns from the experimental CPs were compared with the farmers' CPs and cultivation practices. Enterprise budgeting was used to compare the results of the experimental (E) and farmer (F) CPs (Tables 12 and 13).

In the ***turod,*** the experimental pattern rice-corn-mungbean, consistently generated higher rates of return to labor and power, material inputs and total variable costs than farmers' CPs. The mean marginal benefitsost ratio was **2.90** for the rice-corn-mungbean pattern for three crop years (i.e., for every ₱1.00 increase in variable cost above the farmers' rice-fallow pattern, an increase of ₱2.90 was returned). Tables 12 and 13 show the benefit-cost ratio of shifting farmers' dominant CPs for three crop years.

Technical Feasibility

Credit, labor, marketing and irrigation were major constraints to the adoption of the rice-corn-

Table 12. Cost and returns of cropping patterns in the experimental (E) and farmer's (F) fields by year, *turod* land form. Bantug. [illegible]

Cropping pattern[b]	Cost (₱/ha) Labor and [illegible]	Materials	Irrigation	Total Variable	Yield (t/ha) 1	2	3	Gross returns (₱/ha)	Returns Above variable cost (₱/ha)[c]	To labor and power (₱/₱)[d]	To material cost (₱/₱)[e]	To irrigation cost (₱/₱)[f]	Ratio of gross returns to total variable[g]	Marginal benefit-cost ratio[h] R-F (F)
1984/85[a]														
R-C-M(E)[i]	6543	8990[j]	4434	19967	3.87	2.45	0.92	32254	12287	2.88	2.37	3.77	1.62	1.87
R-C-P(E)[i]	8137	9017	4434	21588	3.71	2.99	0.74	29951	8363	2.03	1.93	2.87	1.39	1.53
R-R (E)[k]	5036	4583	3628	13247	3.35	2.40	-	17327	4080	1.81	1.89	2.12	1.31	1.54
R-F (F)[k]	2307	2318	1565	6290	2.07	-	-	6448	258	1.11	1.11	1.16	1.04	-
1985/86[a]														
R-C-M(E)[l,n]	8201	6191	2402	16794	4.89	4.41	1.13	51408	34614	5.22	6.59	15.41	3.06	3.64
R-C-P(E)[l,n]	4119	4826	1491	10436	4.88	0.00	-	15600	5164	2.25	2.07	4.46	1.49	0.73
R-R (F)[k]	6859	5549	2951	15359	3.89	4.08	-	24032	8673	2.26	2.56	3.94	1.56	1.25
R-F (F)[k]	2640	2150	1280	6070	3.74	-	-	12412	6342	3.40	3.95	5.95	2.04	-
1986/87[a]														
R-C-M(E)[l]	10626	5939	1902	18467	5.25	4.53	1.03	49988	31521	3.97	6.31	17.57	2.71	3.17
R-C-P(F)[k]	8023	2887	1851	12761	4.73	4.80	-	30096	17335	3.16	7.06	10.36	2.36	2.87
R-R (F)[k]	7757	2846	3133	13736	4.24	4.13	-	24455	10719	2.38	4.77	4.42	1.78	1.70
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			12263	5711	2.64	3.97	6.01	1.87	-

[a]Cost of labor, power, materials and irrigation were deflated using the consumer price index (Central Luzon) from 19[illegible]

[b]R = rice, C = corn, M = mungbean, P = peanut, F = fallow

[c]Gross return – Total variable cost

[d][Gross return - (Material + irrigation cost)/(Labor and power cost)]

[e][Gross return - (Labor and power + Irrigation cost)/(Material cost)]

[f][Gross return - (Labor and power + Material cost)/(Irrigation cost)]

[g]Gross return / Total variable cost

[h]Marginal benefit-cost ratio = $\dfrac{\text{(Gross return of potential) – (Gross return of prevalent pattern)}}{\text{(Total variable cost of potential pattern) – (Total variable cost of prevalent pattern)}}$

[i]With IR42 as first crop

[j]An interest rate of 40% for material cost was included

[k]Average of all varieties

[l]With SMC 305 corn variety as second crop

[m]With IR36 as first crop

[n]With IR64 as first crop

Table 13. Cost and returns of cropping patterns in the experimental (E) and fanner's (F) fields by year, *lungog* landform, **Bantug, Guimba**, Nueva Eciia,

Cropping pattern[b]	Cost (₱/ha) Labor and power	Materials	Irrigation	Total Variable	Yield (t/ha) 1	2	3	Gross returns (₱/ha)	Returns Above variable cost (₱/ha)[c]	To labor and power (₱/₱)[d]	To material cost (₱/₱)[e]	To irrigation cost (₱/₱)[f]	Ratio of gross returns to total variable[g]	Marginal benefit-cost ratio[h] R-F (F)
1984/85[a]														
R-R (E)[n]	7568	9239	3628	20615	3.74	1.91	-	23073	2458	1.32	1.26	1.68	1.12	1.14
R-C (F)[k]	5190	4955	3628	13773	3.42	2.99	-	17828	4055	1.78	1.82	2.12	1.29	1.52
R-F (F)	2903	2368	1565	6836	2.38	-		7291	455	1.16	1.19	1.29	1.07	
1985/86														
R-R (E)[n]	3436	1814	1280	6530	4.35	-	-	13922	7392	3.15	5.07	6.71	1.13	2.60
R-C (F)[k]	6963	5008	2995	14966	4.05	4.24	-	24733	9767	2.40	2.95	4.26	1.65	1.39
R-F (F)	2578	1943	1280	5801	3.77	-	-	12028	6227	3.42	4.20	5.86	2.07	
1986/87														
R-R (E)[o]	3479	1309	1140	5224	-			14024	8100	3.33	7.18	8.07	2.37	[illegible]
R-C (F)[k]	7561	3126	2694	13981	4.22	3.97	-	23928	9947	2.31	3.67	4.69	1.71	0.59
R-F (F)	3541	1940	1144	6425	-		-	12200	5575	2.57	3.87	5.87	1.84	

[a]Cost of labor, power, materials and irrigation were deflated using the consumer price index (Central Luzon) from 1984-1987 as base year.
[b]R = rice, C = corn, M = mungbean, P = peanut, F = fallow
[c]Gross return − Total variable cost
[d][Gross return - (Material + irrigation cost)/(Labor and power cost)]
[e][Gross return - (Labor and power + Irrigation cost)/(Material cost)]
[f][Gross return -(Labor and power + Material cost)/(Irrigation cost)]
[g]Gross return / Total variable cost,

$$^{h}\text{Marginal benefit-cost ratio} = \frac{\text{(Gross return of potential)} - \text{(Gross return of prevalent pattern)}}{\text{(Total variable cost of potential pattern)} - \text{(Total variable cost of prevalent pattern)}}$$

[i]With IR42 as first crop
[j]An interest rate of 40% for material cost was included
[k]Average of all varieties
[l]With SMC 305 corn variety as second crop
[m]With IR36 as first crop
[n]With IR64 as first crop

mungbean pattern on a substantial part of the DTW service area, although both DS upland crops in three crop sequences do not require more than 30 man-days/ha during the 180 days DS (Figure 8). If all turod areas were planted to rice-corn-mungbean, whole farm graphing showed that household labor was not enough to meet labor requirements for land preparation, seeding, transplanting and harvesting. However, hired labor was available to meet labor needs.

Infrastructure Support *Credit*

The local Land Bank Office at Guimba extended loans to farmers who would adopt the rice-corn-mungbean pattern during crop year 1987/88. Substantial portion of the *turod* was planted to corn during the 1987 TS (Figure 9). These areas in previous years were either planted to rice as second crop or fallowed. Yields of corn averaged 4.8 t/ha and 2.5 t/ha for rice. Consequently, irrigation fee payment of farmers who planted corn was almost 100% compared to less than 1% of farmers who planted rice as second crop.

Conclusion

Crop production could be increased significantly in the service area of a DTW by crop diversification, i.e., shifting to upland crops l i e corn and mungbean which *require* less water during the dry season. To improve water distribution, there is a need for close coordination of field operations, improvements of on-farm WUE and main system efficiency. There is also a need to reassess irrigation policies and how these are implemented. Alternate cropping pattern, rice-corn-mungbean, maximizes the effective utilization of farm resources and provides greater income to farmers than the current cropping patterns (rice-fallow or rice-rice).

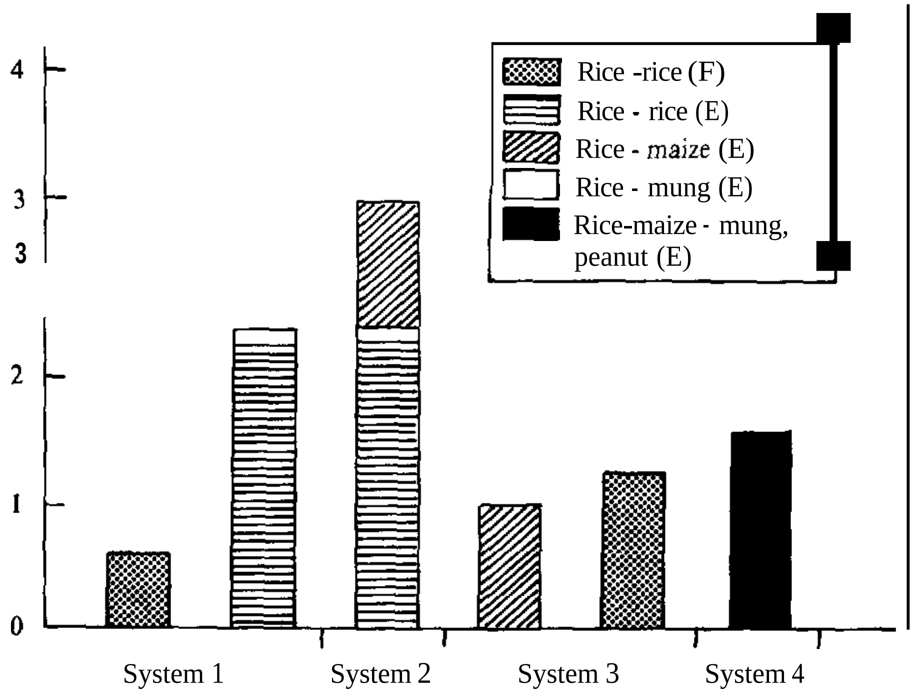

Figure 8. Potential total DS employment from growing alternative cropping systems in the P-27 service area, 50% water use efficiency, Guimba, Nueva Ecija, Philippines, 1984-85.

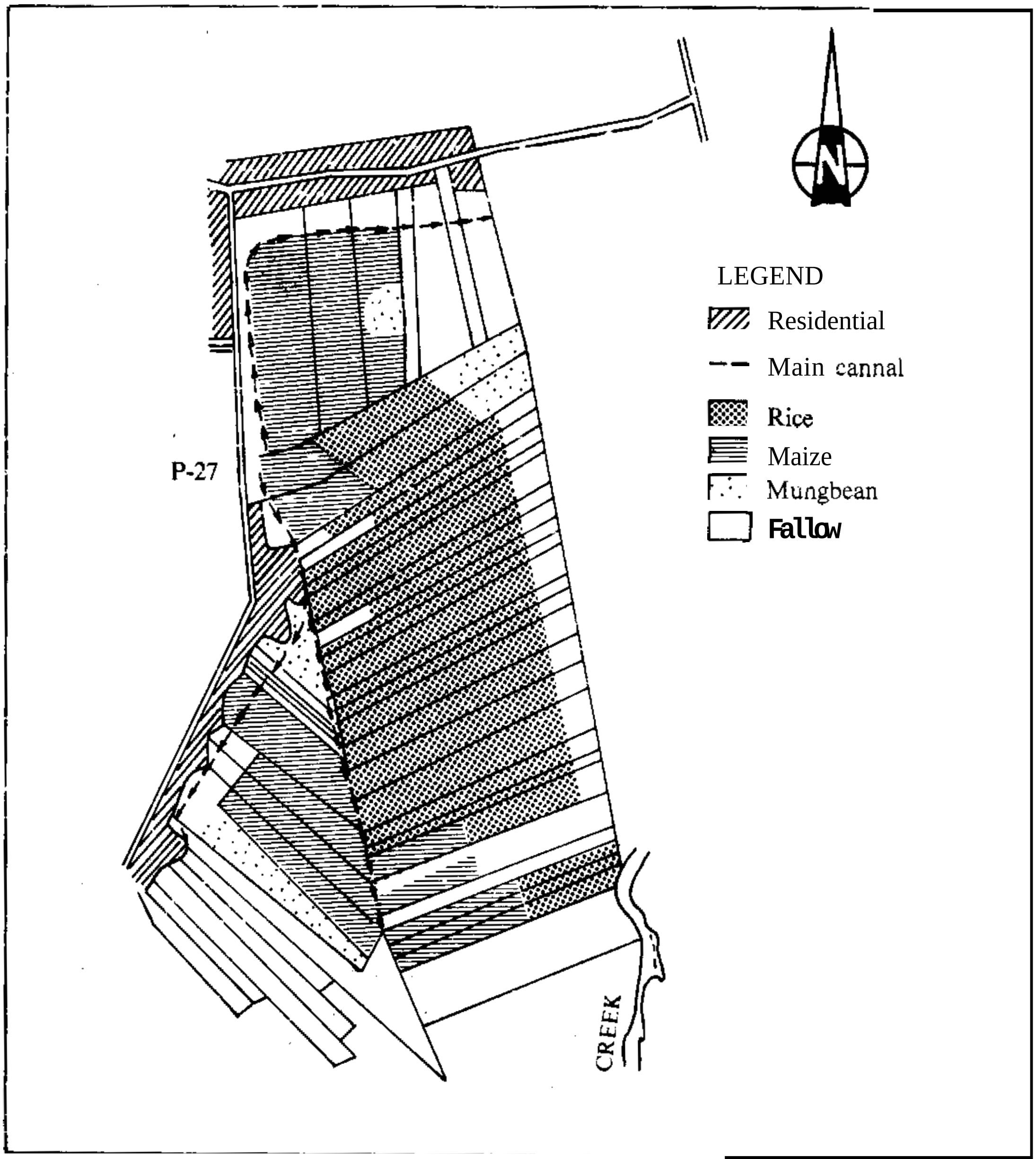

Figure 9. Map showing areas planted to upland crops and rice during the 1988 DS, P-27 service area. Guimba, Nueva Ecija, Philippines.

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High Frequency Basin Irrigation Design for Non-rice Crops in Ricelands

George J. Moridis and Manuel M. Alagcan[1]

Abstract

Rice soils are generally characterized by heavy textures, poor structures, low porosities and permeabilities, shallow traffic pans and slow rates of internal drainage. Growth and yields of non-rice crops in these soils are adversely affected because of restricted root aeration and development. Under these conditions, irrigation of non-rice crops poses serious problems because of further reductions in the air-filled porosity and the soil's tendency to waterlog.

A high frequency basin irrigation method for non-rice crops in rice soils was developed. It was based on a computer solution of the Lewis and Milne surface irrigation volume balance equation by numerically inverting the Laplace transform of the equation. The method provides an optimum design for the alleviation of soil-related adverse effects while enabling a high application efficiency and uniformity.

The method was rested in three different fields in Guimba, Nueva Ecija. Water depths of 0.330, 0.325 and 0.374 meter with design application efficiencies of 90.9, 92.4 and 93.7% were applied in 8, 7 and 10 low volume irrigations, respectively. The corresponding yields were 8.08, 6.14, and 9.17 t/ha, while farmer yields in the area average 2.0-2.5 t/ha.

Introduction

The potential of irrigated upland (non-rice) crops in crop diversification schemes is seldom realized for a number of reasons. These may include:

1. Inadequate or excessive water applications, due to lack of experience with non-rice crops and resulting in low application efficiencies and uniformities. Thus, yields are adversely affected and limited water, energy and financial resources are wasted.
2. Selection of crop inappropriate for the amount of available water and existing market price environment.

These problems are compounded by the physical constraints of rice soils when planted to upland crops. Puddling destroys the soil structure and results in high resistance to root penetration, low porosities and permeabilities and the formation of a shallow traffic pan which further impedes vertical water movement, thus reducing infiltration and percolation rates. The heavier soil textures usually associated with rice soils magnify these problems by restricting drainage and promoting waterlogging. Moreover, such soils tend to crust when irrigated. These conditions reduce root aeration, impede root development of upland crops and adversely affect crop growth and yields. Imgation of upland in rice soils poses formidable problems because of the aforementioned limitations and a much higher level of management is necessary to overcome these deficiencies.

Surface Irrigation Method Selection

Basin irrigation was selected as the most appropriate irrigation method for rice fields. Selection was based on the following considerations:

1. Rice fields are remarkably flat (at least within the paddies) because of the levelling effect of puddling.

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2. The maintenance requirements for basin irrigation are very limited as opposed to furrow irrigation. Operation of the irrigation system is easy and can be easily handled by a single person.
3. Minimal easily-removed modifications to the basic paddy geometry was desired to minimize labor and energy requirements and costs.
4. Previous socio-economic research bas shown that majority of the farmers rely on rented machinery for cultural operations and that the availability of capital is the most important constraint to agricultural production. The simple construction of a basin irrigation system is less expensive and may increase profitability.

The ensuing analysis is based on small, shallow-well (and usually privately owned) pump irrigation systems. These irrigation systems were selected because they allow total water control and management flexibility. However, if reliable water supply at the system level is available, the concepts of this research can be used in larger deep-well systems, as well as surface irrigation systems serving large command areas.

The Mathematical Model

Based on the work of Lewis and Milne (1938) and Davis (1961), the volume balance equation for basin imgation is

$$Q_u = C_s \cdot l + \int_0^l fz(t_{op})dx \tag{1}$$

where

$$Q_u = \frac{Q}{W} \tag{2}$$

Q = the inflow rate ($m^3 . sec^{-1}$);
Q_u = the stream size ($m^3 . sec^{-1}$);
t_l = the stream advance time to reach a distance l from the inlet (sec);
W = the basin width (m);
C_s = the surface storage (m);
$fz_{(t)}$ = cumulative infiltration function (m);
t_{op} = the infiltration opportunity time (see);

and

$$t_{op} = t_l - t_x \tag{3}$$

where tx is the advance time to distance x from the inlet (Figure 1).

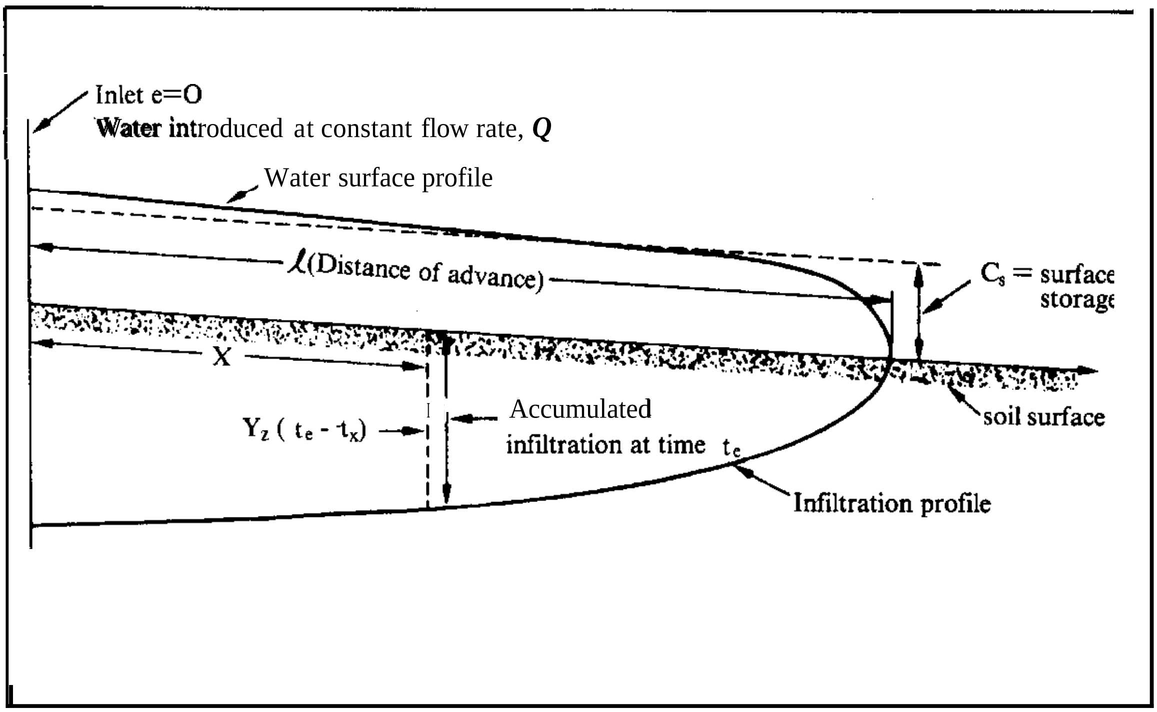

Figure 1. Water profiles the advance phase of basin irrigation.

In equation (1) C_s represents the average depth of water at the soil surface and is a function of time. Ley (1978) and Wilke and Smerdon (1965) indicated that C_s can be assumed independent of time when the surface stream wetting front has advanced a significant distance. This significant distance depends on the field's hydraulic characteristics, i.e. slope, flow rate, roughness and infiltration. In most cases C_s can be considered constant after the wetting front has advanced over 100 m. Rice paddies are seldom that long. Moreover, experience indicated that basin lengths shorter than 100 m are needed in order to achieve application uniformity and water economy and avoid waterlogging. Therefore, C_s cannot be assumed constant. In order to avoid the problem of C_s time dependence in the analysis, C_s is treated as piecewise constant, i.e. constant between two successive points in time but changing over time. This approach was proven satisfactory. The surface storage is computed as

$$C_s = 0.9\ . n^{3/8} Q_u^{9/16}\left[(t_{m,l})_n^{3/16} + (t_{m,l})_{n-1}^{3/16}\right], \qquad (4)$$

where

n = the Manning roughness coefficient;
$(t_{m,l})_n$ = the time of current calculation (min);
$(t_{m,l})_{n-1}$ = the time of last calculation (min).

The integral in equation (1) becomes

$$\int_0^{t_l} fz(t_l - t_x)\,dx = \int_0^{t_l} fz(t_l - t_x) l'(t_x) dt_x \qquad (5)$$

where

$$l'(t) = \frac{dl}{dt} \qquad (6)$$

Combining equations (1) and (5), we obtain:

$$\underbrace{Q_u \cdot t_l}_{TWV} = \underbrace{C_s \cdot l}_{SSV} + \underbrace{\int_0^{t_l} fz(t_l - t_x) l'(t_x) l'(t_x) dt_x}_{I} \qquad (7)$$

and TWV, SSV and I represent the total water volume admitted to the basin, the surface storage volume and the total volume of infiltrated water.

Philip and Farrel (1964) determined that equation (7) is valid if l is a monotonically increasing function of t_l, a condition which places a restriction on the form of fz. Sufficient conditions are:

$$fz \geq 0,\ \frac{dfz}{dt} \geq 0,\ \text{and}\ \frac{d^2 fz}{dt^2} \geq 0. \qquad (8)$$

These conditions are generally met and equation (1) is valid.

Applying the Laplace transform to both sides of equation (7), we have:

$$L\{Q_u \cdot t_l\} = L\{C_s \cdot l\} + L\left\{\int_0^{t_l} fz(t_l - t_x) l'(t_x) dt_x\right\} \rightarrow$$

$$\frac{Q_u}{s^2} = Cs \cdot L\{l\} + L\left\{\int_0^{t_l} fz(t_l - t_x) l'(t_x) dt\right\} \qquad (9)$$

Using the convolution theorem

$$L\left\{\int_0^{t_l} fz(t_l - t_x) l'(t_x) dt_x\right\} = L\{fz\}\ .\ L\{l'\}. \qquad (10)$$

From the properties of Laplace transforms

$$L\{l'\} = sL\{l\} - l(0) = sL\{l\} \qquad (11)$$

because $l(0) = 0$.

Combining equations (9), (10) and (11) and solving for $L\{l\}$, we obtain:

$$L\{l\} = \frac{Q_u}{s^2 Cs + s^3 L\{fz\}} \qquad (12)$$

From a large number of field tests the infiltration of rice soils was determined to be of the form

$$fz = a \cdot t_m^b + c = a\left(\frac{t}{60}\right)^b + c;\ 0 \leq b \leq 1;\ t > 0 \qquad (13)$$

where

a, *b*, *c*, = constants, and t_m = elapsed time (min).

Taking the Laplace transform of equation (13),

$$L\{fz\} = \frac{a\Gamma(b+1)}{(60)^b s^{b+1}} + \frac{c}{s} \qquad 14$$

where Γ denotes the gamma function. Substitution in equation (12) and rearrangement yields:

$$L\{l\} = \frac{Q_u}{\omega s^{2-b} + (C_s + c)s^2} \qquad (15)$$

where

$$\omega = \frac{a\Gamma(b+1)}{(60)^b}$$

The expression for l can then be determined by taking the inverse Laplace transform of equation (15), i.e.

$$\overline{\omega s^{2-\sigma} + (C_s + c)s^2}$$

The inverse Laplace transform in equation (16) cannot be readily be found. For $c = 0$, ***Philip*** and ***Farell*** [1964] obtained the following analytical solution for l:

$$l(t_l) = \frac{Q_u \cdot t_l}{(C_s + c)} \sum_{m=0}^{\infty} \frac{\left[\frac{-a\Gamma(1+b)t_l^b}{(C_s+c)}\right]^m}{\Gamma(2+mb)} \tag{17}$$

This solution is valid for small t's. Moreover, calculations are complicated for large values of $at^b/(C_s + c)$ because the magnitude of the individual terms becomes very large. The series alternates in sign and accumulates as differences of very large numbers, which may result in round-off errors.

Equation (16) was inverted numerically by using the *Stehfest* [1970] method. The scheme was based on the following equations:

$$s_i = \frac{ln2}{t_l} i \,, \tag{18}$$

$$l(t_l) = \frac{ln2}{t_l} \sum_{i=1}^{N} V_i \cdot L\{[l(s_i)]\} \,, \text{ and} \tag{19}$$

$$V_i = (-1)^{\frac{N}{2}+i} \sum_{k=\frac{i+1}{2}}^{\min(i,N/2)} \frac{k^{N/2}(2k)!}{(\frac{N}{2}-k)!k!(k-1)!(i-k)!(2k-i)!} \tag{20}$$

For double precision variables the optimum value for N is $N = 18$. The $L\{[l(s_i)]\}$ in equation (19) is obtained from equation (15).

The calculations yield pairs of $(t_l,l)_1, (t_l,l)_2, \ldots, (t_l,l)_n$ and proceed until the field length L is reached. The time of advance t_a, i.e. the time corresponding to the field length L cannot be determined directly and an interpolation procedure has to be used. Once the advancing water front reaches L, the advance ceases due to the physical restriction of ridges or bunds and the surface storage C_s increases rapidly. Under these circumstances equation (1) is no longer valid and the infiltration volume is given by the equation

$$I = \int_0^L fz(t - t_l)dl, \qquad t \geq t_L \,. \tag{21}$$

No analytical expression is available for $t_l = t_l(l)$. Therefore, I has to be evaluated numerically using the data points $(t_l,l)_2, (t_l,l)_2, \ldots, (t_l,l)_{nL}$, where nL the data point number corresponding to the end of the field.

The determination of the 'cut-off time' l, (sometimes called the 'application time?, the 'basinwide opportunity time' t_{opb} (defined as the time required for water to infiltrate in the basin), the application efficiency E_a (defined as the fraction of the water applied to a field which remains within a management defined soil zone) depends on the design parameter used as the measure of water application. Three cases can be identified:

Case I: Given Gross Application Depth d_{gr}

The cut-off time t_{co} is calculated as

$$t_{co} = \frac{L \cdot d_{gr}}{Q_u} \tag{22}$$

The basinwide opportunity time t_{opb} is then determined from the equation

$$I_T = Q_u \cdot t_{co} = \int_0^L fz(t_{opb} - t_l)dl, \tag{23}$$

where I_T the total infiltration volume. Since there is no analytical expression for t_l, t_{opb} cannot be analytically determined and an interpolation procedure must be used.

The average application depth d_{avg} is calculated from

$$d_{avg} = \frac{I_T}{L} \tag{24}$$

With reference to Figure **2** the application efficiency E_a is then

$$E_a = \frac{V_1}{V_1 + V_2} \text{ or } E_a = \frac{d_{avg}}{d_{gr}} \,, \tag{25}$$

where V_1 is the volume of water above d_{avg} and V_2 the volume of water which infiltrates below d_{avg}.

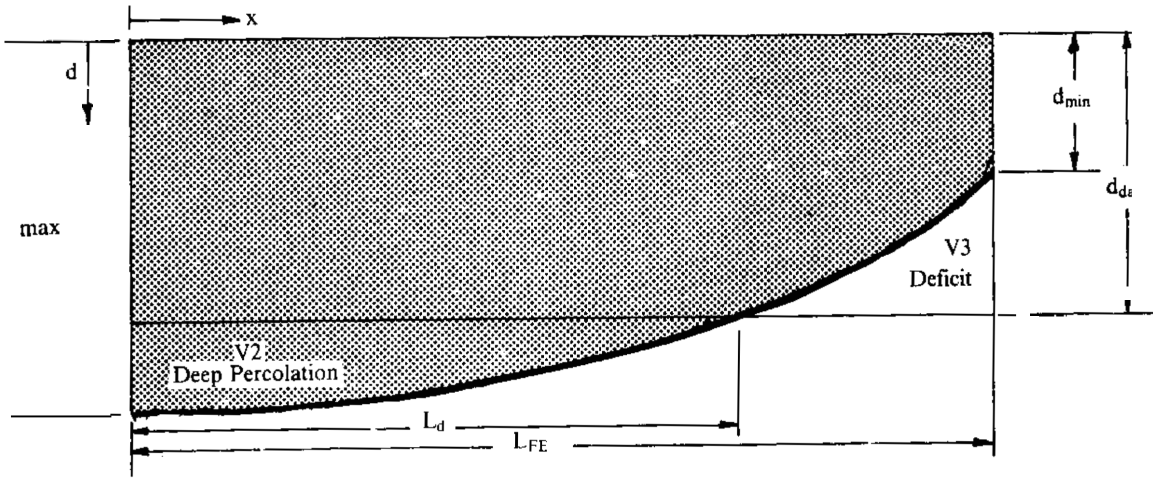

Figure **2.** Infiltrated depth profile.

Case 2: Given Desired Application Depth d_{da}

The basinwide opportunity time t_{opb} is determined from

$$d_{da} \cdot L = \int_0^L fz(t_{opb} - t_l)dl \; . \qquad (26)$$

An interpolation procedure must be used since t_{opb} cannot be computed analytically.

With reference to Figure 2,

$$E_a = \frac{V_1}{V_1 + V_2} = \frac{d_{da}}{d_{gr}}, \qquad (27)$$

where V_1 and V_2 the water volumes above and below d_{da}. From (27)

$$d_{gr} = \frac{d_{da}}{E_a}, \qquad (28)$$

and

$$t_{co} = \frac{L \cdot d_{gr}}{Q_u} \qquad (29)$$

Case 3: Given Minimum Desired Application Depth $(d_{da})_{min}$

This corresponds to a desired application depth at $l = L$. *The opportunity time at L is*

$$(t_{op})_L = \left[\frac{(d_{da})_{min} - c}{a}\right]^{\frac{1}{b}},$$

and the basin wide opportunity time is then

$$t_{opb} = t_l + (t_{op})_{min} \; . \qquad (30)$$

The total infiltration is then given by

$$I_T = \int_0^L fz(t_{opb} - t_l)dl \, , \qquad (31)$$

and

$$d_{avg} = \frac{I_T}{L}, \qquad (32)$$

$$t_{co} = \frac{I_T}{Q_u}, \qquad (33)$$

$$E_a = \frac{V_1}{V_1 + V_2} = \frac{(d_{da})_{min}}{d_{avg}} \qquad (34)$$

A computer program was written in FORTRAN **77** to carry out the necessary calculations for the study. For maximum accuracy double precision variables were used.

The infiltration volumes (equations of the type of equation [21]) were calculated using acuhic spline interpolation of the data points $(t_i, l)_i$, $i = 0, 1, \ldots, nL$ and integrating the resulting quadratic equations over the distance$[0, L]$. These calculations begin when i = **4** and proceed until the value of I **has** been bracketed. **A** linear interpolation was then **used** to determine the unknown t_{opb}.

Considerations and Constraints

The design of an efficient basin irrigation system for upland crop irrigation in ricelands must meet the following requirements:

1. Minimization of deep percolation for water and energy conservation.
2. Alleviation of waterlogging. which is a frequent and serious constraint lo upland production. The problem is addressed by ensuring that infiltrated water does not reach the traffic pan. It was found that the depth of ricefield traffic pans ranged from 0.15-0.20 m from the soil surface and the water-fillable porosity was roughly $\phi_{wf} = 33\%$. Assumingthat the minimumdepth to the traffic pan $(D_{tp})_{min} = 0.15\ m$, the maximum permissible water application depth (for waterlogging alleviation) is

$$d_{max} = \phi_{wf} \cdot (D_{tp})_{min} = 0.05\ m\ (= 50mm) \qquad (35)$$

   Water application of less than 0.03 m were determined to be operationally inefficient, requiring an excessive number of irrigation and small basin dimensions which **is** not practical. This determines the minimum permissibie application depth $d_{min} = 0.03$ m. Application dcptbs have to fall between these two extremes, i.e.

$$d_{min} \leq d_{da} \leq d_{max} \rightarrow 0.03 \text{ m} \leq d_{da} \leq 0.05 \text{ m}. \qquad (36)$$

   The condition **in** equation (36) dictate **a** high number of low volume irrigation to supply the same quantity of water required by the crop, thus, defining a high frequency basin irrigation method.
3. High application efficiency, E_a. For the size, dimensions and, hydraulic characteristics of the bunded rice-field basins or sub-basins, the minimum acceptable application efficiency $(E_a)_{min} = 85\%$. For design purposes $(E_a)_{dsn} \geq 90\%$.
4. High uniformity. Objectives 3 and **4** aim to minimize water and energy losses and their associated costs, and to maximize crop yields. Design for these two objectives has to account for the following variabilities:
   a. Infiltration characteristics variability, both spatial and in time, as quantified by the variability in parameters ***a, b,*** and c of the infiltration equation.
   b. Space and time variability of the hydraulic characteristics of the soil surface, **as** quantified by the Manning roughness coefficient ***n.***
   c. Variability of the flow rate of the water supply.

The irrigation system for upland crops in ricelands was designed to determine sub-basin dimensions capable of accommodating considerable changes in the values of any combination of the uncertainties described above without a significant decrease in application efficiency.

Design Procedure

The design procedure is based on **a** "worst case" scenario **as** follow:

1. Parameters ***a, b*** and c of the infiltration equation and their corresponding range of values are determined through **a** number of tests. The double ring infiltrometer is the most appropriate apparatus because of its simplicity and the similarity of its principle to the conditions pertaining to basin irrigation.

   Of the three parameters, c **has** the most pronounced effect on E_a because of its magnitude and variability, while *a* and ***b*** do not exhibit large variations. In a number of infiltration tests conducted under a different experiment, the value of c ranged from 0.002-0.023 m; at the study site, values ranged from 0.005-0.018 m. The value of c depends on soil texture, moisture content, **as** well **as** land preparation practices and the corresponding time elapsed since the end of the activity. The largest value of c corresponds to the lowest E_a and is used for the design. The value of c is usually at its highest, immediately after the end of land preparation, i.e., at the first irrigation. If infiltration tests cannot be conducted and there is no information, a design **c** value of 0.015 - 0.017 meter is adequate for the conditions of most **rice** fields.

2. The Manning roughness coefficient n is determined. Table I shows the values of n for some soil surface conditions and crops. It was found that n was not important for a well harrowed field. Therefore, n = 0.05 is sufficiently accurate for corn throughout the growing season.

Table I. Common Manning Roughness Coefficient n Used in Basin Irrigation Design.

Smooth, bare soil surface non-cultivated	0.04
Small grain, drill rows parallel to direction of water flow	0.10
Broadcast small grains	0.15
Dense sod crops, small grains with drill rows across the water flow direction	0.25

3. The minimum available well flow rate is determined and used as the design rate. However, well flow rate may change considerably during the growth season because of possible interferences from other wells, evapotranspiration and drainage, which lower the water table. Historical data may be used for the determination of Q_{min}. If these are not available, the design flow rate is taken **as**

$$Q_{dsn} = Q_{min} \simeq \frac{Q_{max}}{2}$$

where Q_{max} the well flow rate at the beginning of the dry season and easily determined through a simple well test.

4. The minimum permissible application depth d_{min} is taken as the design application depth, i.e.

$$d_{dsn} = d_{min} = 0.03 \text{ m} \tag{38}$$

5. The design application efficiency $(E_a)_{dsn}$ is set at

$$(E_a)_{dsn} = 90\%. \tag{39}$$

If ample water supply is available and the soil is a silty clay loam or lighter, $(E_a)_{dsn}$ may be taken as low as **80%.**

The values of these design parameters were determined under the "worst case". Any changes in value indicate an improvement and results in higher E_a. While this is a conservative approach, it was deemed necessary to overcome the extreme sensitivity of rice soils to waterlogging.

Using the above parameters and the computer solution of the Lewis and **Milne** equation, the values of t_{co}, t_a, and E_a were determined for a wide combination of the basin dimensions, W and L. The resulting families of curves are plotted in figure 3 (with $Q_u = Q/W$ as the independent variable) and in figure **4** (with L **as** the independent and $Q_u/L = Q/(W \cdot L)$ = Q/A **as** the dependent variable).

Using these curves, the basin dimensions for a desired d_{dsn} can be determined. For practical purposes, the basin width $W \geq 4$ m. The process can be repeated for a number of different desired application depths d_{dsr} and graphs similar **to** figures 3 and **4** can be developed. If the infiltration equation does not change significantly with time, the graphs can be used to determine t_{co} and t_a for subsequent irrigations and to evaluate the performance of the irrigation system. If the infiltration equation changes significantly with time, then the computer program has to be used to perform these tasks.

The following demonstrate how the graphs in figures 3 and **4** were used in the design procedure:

Example 1: Basin Irrigation Design

The infiltration equation for a rice field is $fz = 0.003 \cdot t_m^{0.5} + 0.006$ (t_m in min, fz in **m**) and the available water flow rate is $Q = 5.0 \times 10^{-3}\ m^3/\text{sec}^{-3}$. Assuming that the remaining design parameters are the same as in the section "DESIGN PROCEDURE", determine

a. the sub-basin length L if the desired W = 10 m,
b. the sub-basin width W if the desired L = 20 m,
c. L and W if the desired sub-basin area is A = 160 m^2

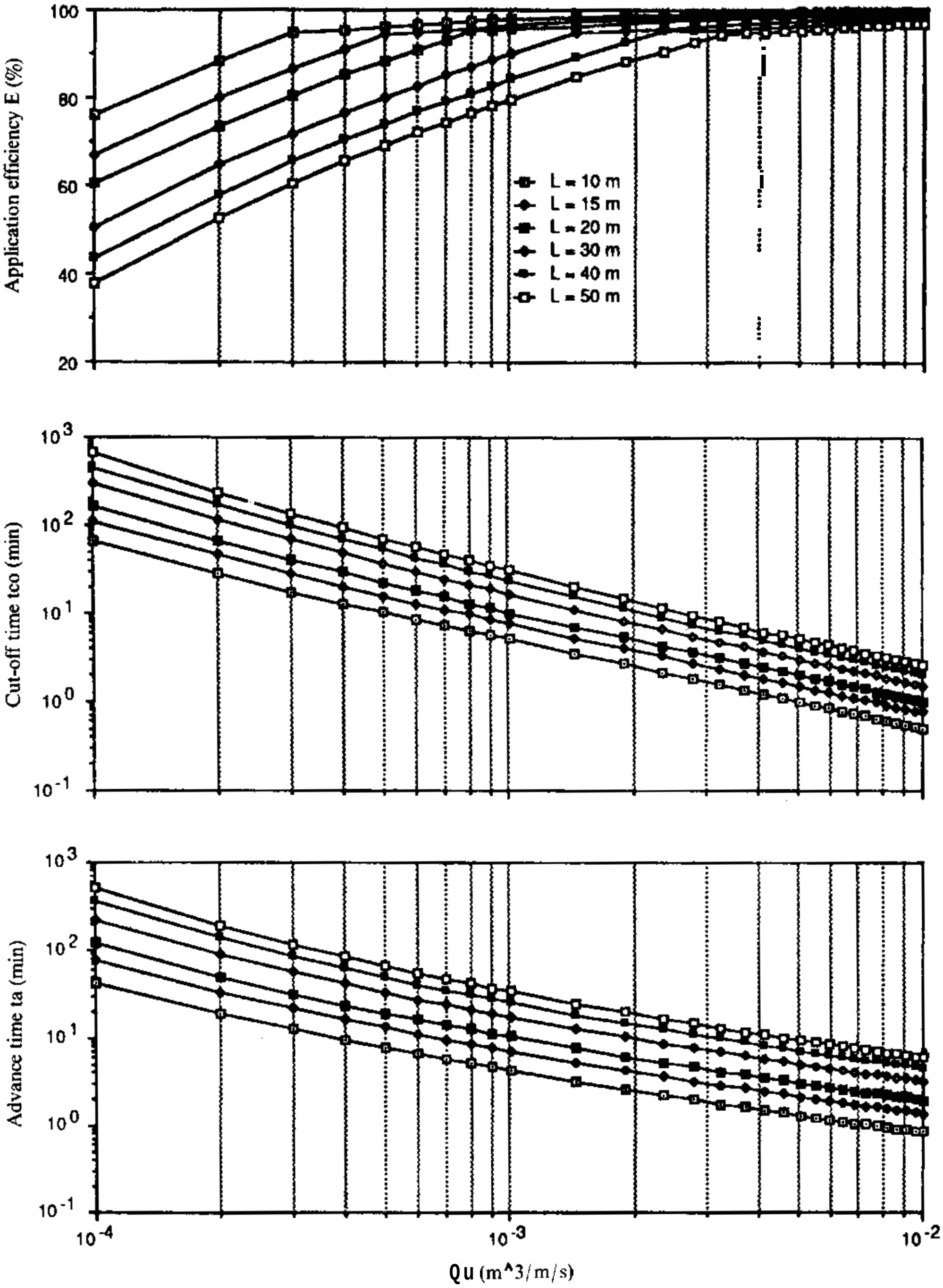

Figure 3. **Application efficiency** E_a, **cut-off time** t_{co} **and time** of **advance** t_a curves for **a desired** application $d_{da} = 0.003\,m$ **when** the **infiltration equation** is $f_z = 0.003 \cdot t_m^{0.5} + 0.006$.

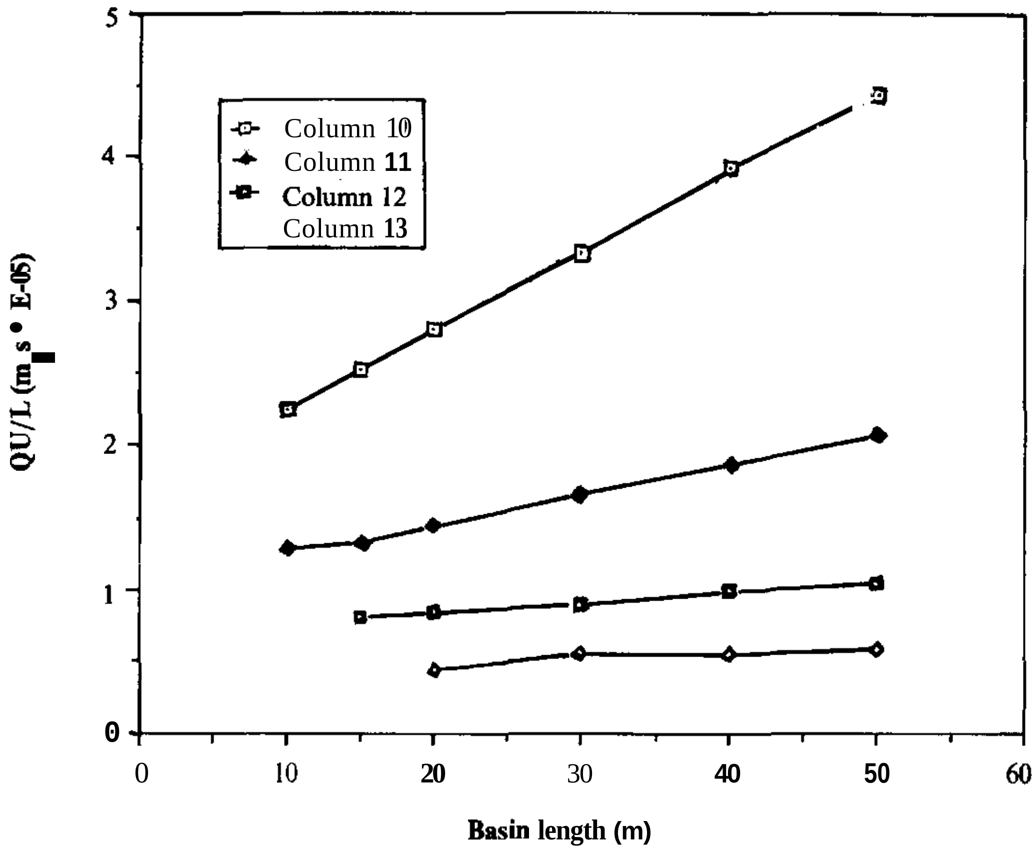

Figure 4. Q_u/L vs. basin length L curves for a desired application $d_{da} = 0.003\ m$ when the infiltration equation is $fz = 0.003 \cdot t_m^{0.5} + 0.006$.

Using the computer solution of the Lewis and Milne equation and the procedure already described, the graphs in figure 3 was obtained.

Case a: *For* $Q_u = Q/W = 5.0 \times 10^{-3}/10 = 5 \times 10^{-4} m^2 sec^{-1}$ and $(E_a)_{dsn} = 90\%$, and from Figure 3(a) we obtain

$$L = 24\ m.$$

Case b: For $L = 20$ m, $(E_a)_{dsn} = 90\%$ and from Figure 3(a) we have

$$Q_u = 5.7 \times 10^{-4}\ m^2 sec^{-1} = Q/W \rightarrow W = 8.77\ m.$$

Alternatively, for $L = 20$ m, $(E_a)_{dsn} = 90\%$ and from Figure 4 we have

$$Q_u/L = 2.83 \times 10^{-5} = \frac{Q}{W \cdot L} \rightarrow W = 8.83\ m$$

Case c: For $A = 150\ m^2$ we have $Q_u/L = Q/A = 3.125 \times 10^{-5}$. From Figure 4 and for $(E_a)_{dsn} = 90\%$,

$$L = 25\ m \text{ and } W = A/L = 6.4\ m$$

Example 2: Basin Irrigation Operation

The sub-basin dimensions of a field are $L = 20$ m and $W = 10$ m. The rest of the parameters remain as in Problem 1. If the desired application depth $d_{da} = 30$ mm, determine E_a, t_{co}, and t_a.

The stream size $Q_u = Q/W = 5 \times 10^{-3}/10 = 5 \times 10^{-4}\ m^2\ sec^{-1}$. For $L = 20$ m, we obtain:

from figure 3(a): $E_a = 88\%$
from figure 3(b): $t_{co} = 23$ min, and
from figure 3(c): $t_a = 20$ min

Example 3: Evaluation *of* Basin *Irrigation Efficiency*

For the sub-basin **of** Example 2, the observed advance time $(t_a)_{obs}$ was 14 min instead **of** the estimated t_a = 20 min. Determine the application efficiency of the system.

From Figure 3(c) and for $(t_a)_{obs} = 14$ min, $Q_u = 5 \times 10^{-4}$ m^2 sec^{-1}, an "apparent length" was obtained L_a = 15 m, which was the length of a basin with the same Q_u and advance time $t_a = (t_a)_{obs}$ as the basin in question. For the same Q_u and $L = L_a = 15$ m, Figure 3(a) yields $E_a = 94\%$, which was the actual application efficiency of the system.

Field Testing The Method

The method was tested for corn irrigation in three different rice fields (Figures 4a, 4b and 4c) in Guimba, Nueva Ecija during the 1987/88 dry season. The first (FI) and second (F2) fields were previously planted to corn and had sandy loam and clay soil, respectively. The third (F3) field had clay loam soil and was previously to rice.

Land preparation consisted of plowing and two harrowing operations. Infiltration measurements were taken after land preparation and the infiltration parameter values obtained were used in the design. The irrigation system layouts were developed using the procedure and the computer program earlier described.

Hybrid corn (PIONEER N115R) wasplanted in rows at 0.80 m apart, and at 0.20 m between hills. NPK fertilizer was applied at a rate of 110:60:40 kg/ha. Since corn was a relatively new dry season crop in the area, plants were remarkably free of diseases and insects commonly associated with corn. The extremely low infestation level was also attributed to the basin irrigation method which offered the advantage of water ponding in the basins for periods longer than 20 min (the limit of viability of most soil-borne insects). Weed infestation was a problem in F1 which was not planted to rice during the previous wet season. Weed infestation was moderate to low in F2 and F3. Weeds were controlled using herbicide application and by manual weeding. Once full cover had been achieved, weeds were not aproblem. In F2 and F3, which had heavier soils, there was a need to break the soil crust that formed after irrigation.

All three fields were supplied with water from shallow (10 m deep) and privately owned wells. F3 was well irrigated during the entire growing period. The pumps at FI and F2 developed mechanical problems later in the season and water had *to* be supplied from a deep, high-output communal well serving the area.

A number of infiltration measurements were taken in the fields prior to irrigation. It was determined that the infiltration parameters of equation (21) demonstrate the largest changes during the first month after land preparation. After this period changes in individual parameters were observed but they were moderate and the cumulative infiltration volume vs. time did not change.

The principle behind the high frequency basin irrigation method was based on the replacement of the moisture depleted from the top 0.15-0.20 m of the soil. Irrigation scheduling was based on evapotranspiration water losses. The FAO version of the Class A Evaporation Pan method [Doorenbos and Pruit, 1974] was used to determine soil moisture losses. Irrigation water was applied when the actual cumulative evapotranspiration since the previous irrigation had reached 30-50 mm. A computer program was used to determine both theoretical and actual values off,,,, t_a and E_a for all irrigations. The irrigation schedules for F1, F2 and F3, as well as other related information arc presented in Tables 2, 3 and 4.

Results and Conclusions

A measure of the efficiency of the design of the basin irrigation system is based on the observed advance time $(t_a)_{obs}$ as opposed to the theoretically calculated t_a. The expected variability in the irrigation design parameters neccesitates that the calculated values of $(t_a)_{dsn}$ and $(E_a)_{dsn}$ for the original design and the t_a and E_a for subsequent irrigations be treated not as optimum values but as threshold values. Therefore, the efficiency of the system was not measured by the proximity of the observed values to the calculated ones, but by their very divergence. The largest the difference,

$$\Delta = (t_a)_{dsn} - (t_a)_{obs} \quad \text{or} \quad \Delta = t_a - (t_a)_{obs}, \qquad \Delta \geq 0$$

the shorter it takes for water to reach the end of the field (thus allowing more time for a more uniform infiltration) and the higher the application efficiency.

Observed vs. calculated advance times for sub-basins in the three fields are presented in

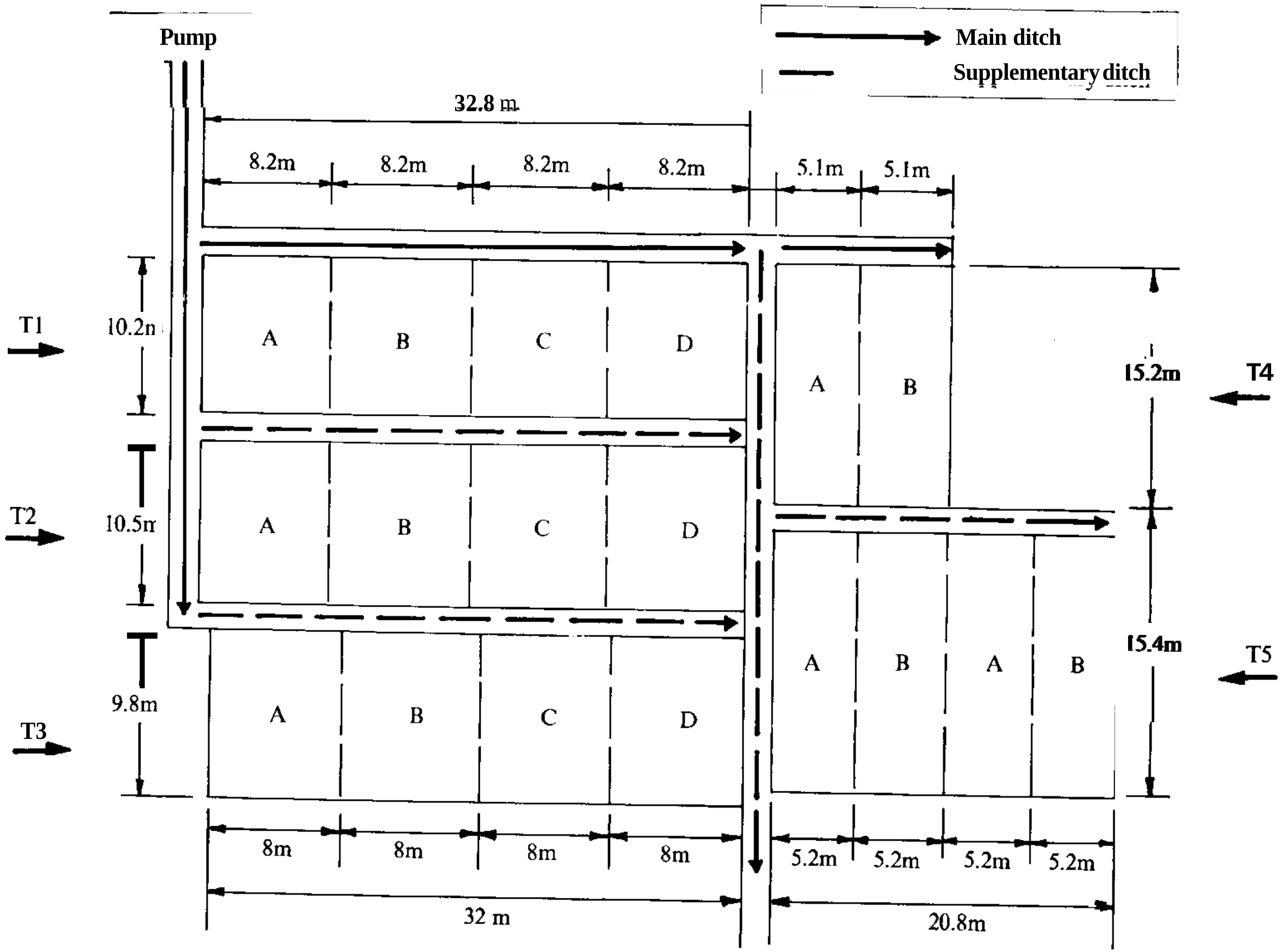

Figure 4a. Field layout of Fl site (Ignacio Acapuyan), Bantug, Guimba, Nueva Ecija

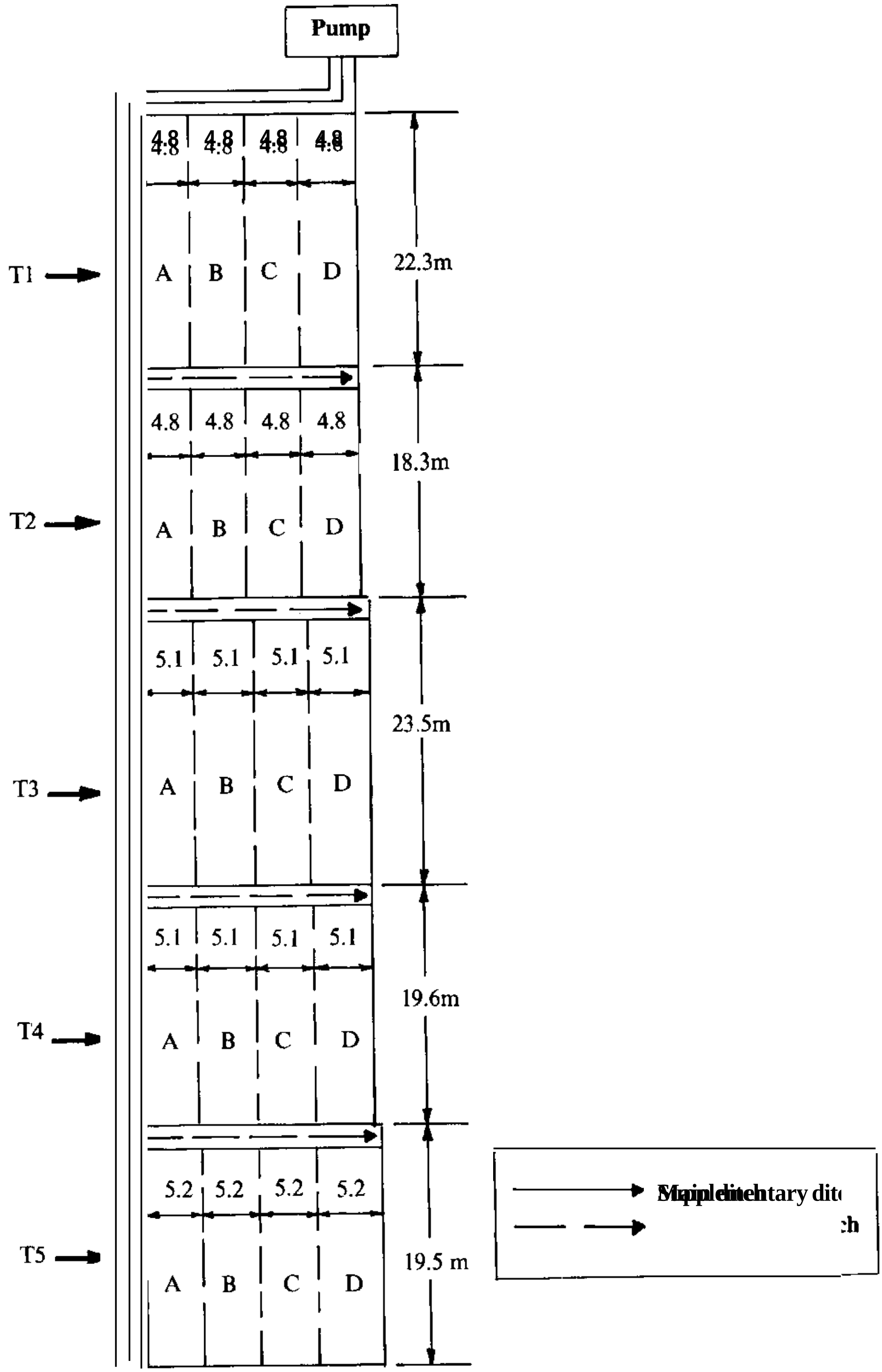

Figure 46. Field layout of F2 site (Alfonso Gragasin), Bantug, Guimba, Nueva Ecija.

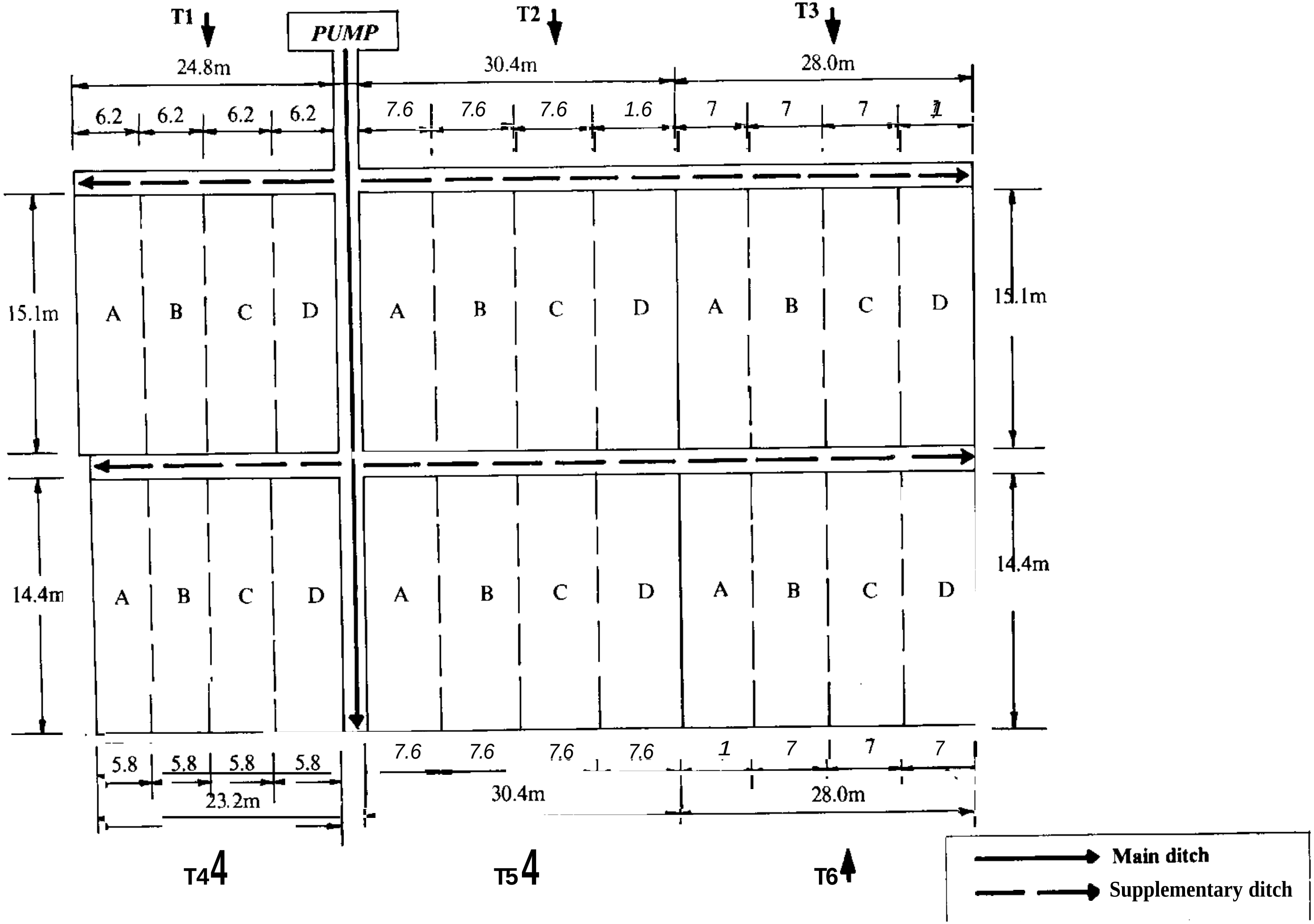

Figure 4c. Field layout of F3 site (Edwin Gragasin), Bantug, Guimba, Nueva Ecija.

Table 2. Irrigation schedule and related information for field F_1, Bantug, Guimba, Nueva Ecija.

Irrigation No.	Date d/m/y	Flow Rate ($m^3 sec^{-1}$)	Infiltration Equation-mm $fz=at_m^b+c$	Desired Application Depth (m)	Gross Application Depth (m)	Application Efficiency (%)
Date of planting: Nov. 18, 1988			Number of sub-basins = 18			
Preplant*	14/11/87	*	*	0.040	0.049	81.6
1	23/11/87	13×10^{-3}	$2.93t_m^{0.47}+12.4$	0.040	0.044	90.8
2	11/12/87	4×10^{-3}	$2.61t_m^{0.50}+9.13$	0.040	0.043	93.0
3	29/12/87	4×10^{-3}	$2.61t_m^{0.50}+9.13$	0.050	0.054	92.6
4	06/01/88	4×10^{-3}	$5.78t_m^{0.30}+5.91$	0.030	0.033	90.9
5	15/01/88	4×10^{-3}	$2.93t_m^{0.48}+8.76$ $9.10t_m^{0.23}+2.48$	0.040	0.043	93.0
6	22/01/88	4×10^{-3}	$2.93t_m^{0.47}+8.76$ $9.10t_m^{0.23}+2.48$	0.030	0.032	93.8
7	29/01/88	5×10^{-3}	$2.93t_m^{0.48}+8.76$ $9.10t_m^{0.23}+2.48$	0.030	0.032	93.7
Total				0.300	0.330	90.9

'Before the construction of the irrigation system.

Table 3. Irrigation schedule and related information for field F_2, Bantug, Guimba, Nueva Ecija.

Irrigation No.	Date d/m/y	Flow Rate ($m^3 sec^{-1}$)	Infiltration Equation-mm $fz=at_m^b+c$	Desired Application Depth (m)	Gross Application Depth (m)	Application Efficiency (%)
Date of planting: Dec. 22, 1988			Number of sub-basins = 20			
Preplant*	17/12/87	*	*	0.040	0.046	86.9
I	29/12/87	5×10^{-3}	$22.9t_m^{0.11}+12.5$	0.050	0.055	90.9
2	08/01/88	5×10^{-3}	$22.9t_m^{0.11}+12.5$	0.050	0.054	92.6
3	15/01/88	4×10^{-3}	$22.3t_m^{0.46}+17.96$	0.050	0.053	94.3
4	22/01/88	$5\text{-}6 \times 10^{-3}$	$0.184t_m+16.94$	0.040	0.043	93.0
5	29/01/88	$3\text{-}5 \times 10^{-3}$	$0.153t_m+12.53$	0.040	0.043	93.0
6	08/02/88	5×10^{-3}	$0.03t_m+15.79$	0.030	0.032	93.8
	No further irrigations because of high water table					
Total				0.300	0.325	92.4

'Before the construction of the irrigation system.

figures 5 to 7. $(t_a)_{obs}$ values smaller than their calculated ta's appear as data points below the 1:1 line while the opposite occurred for the E_a's. For total number of sub-basin irrigations, the irrigation systems performed more efficiently than their intended design in 91% of the cases. This was observed in all fields. This indicated that the "worst case" scenario in which the design had been based

Table 4. Irrigation schedule and related information for field F_3, Bantug, Guimba, Nueva Ecija.

Date of planting: Dec. 23, 1988				Number of sub-basins = 24		
Irrigation No.	Date d/m/y	Flow Rate ($m^3 sec^{-1}$)	Infiltration Equation-mm $fz=at_m^b+c$	Desired Application Depth (m)	Gross Application Depth (m)	Application Efficiency (%)
Preplant*	17/12/87	*	*	0.040	0.045	88.9
1	29/12/87	6×10^{-3}	$0.79t_m^{0.64} + 13.85$	0.050	0.054	92.6
2	08/01/88	6×10^{-3}	$1.39t_m^{0.49} + 13.27$	0.030	0.032	93.8
3	15/01/88	6×10^{-3}	$0.69t_m + 17.06$	0.030	0.032	93.6
4	22/01/88	5×10^{-3}	$0.054t_m + 17.09$	0.040	0.043	93.0
5	29/01/88	5×10^{-3}	$0.075t_m + 15.91$	0.040	0.042	95.2
6	08/02/88	4×10^{-3}	$0.048t_m + 13.54$	0.030	0.032	93.8
7	16/02/88	6×10^{-3}	$0.184t_m + 13.00$	0.030	0.031	96.8
8	23/02/88	5×10^{-3}	$0.184t_m + 13.00$	0.030	0.032	93.8
9	03/03/88	5×10^{-3}	$0.184t_m + 13.00$	0.030	0.031	96.8
Total				0.350	0.374	93.2

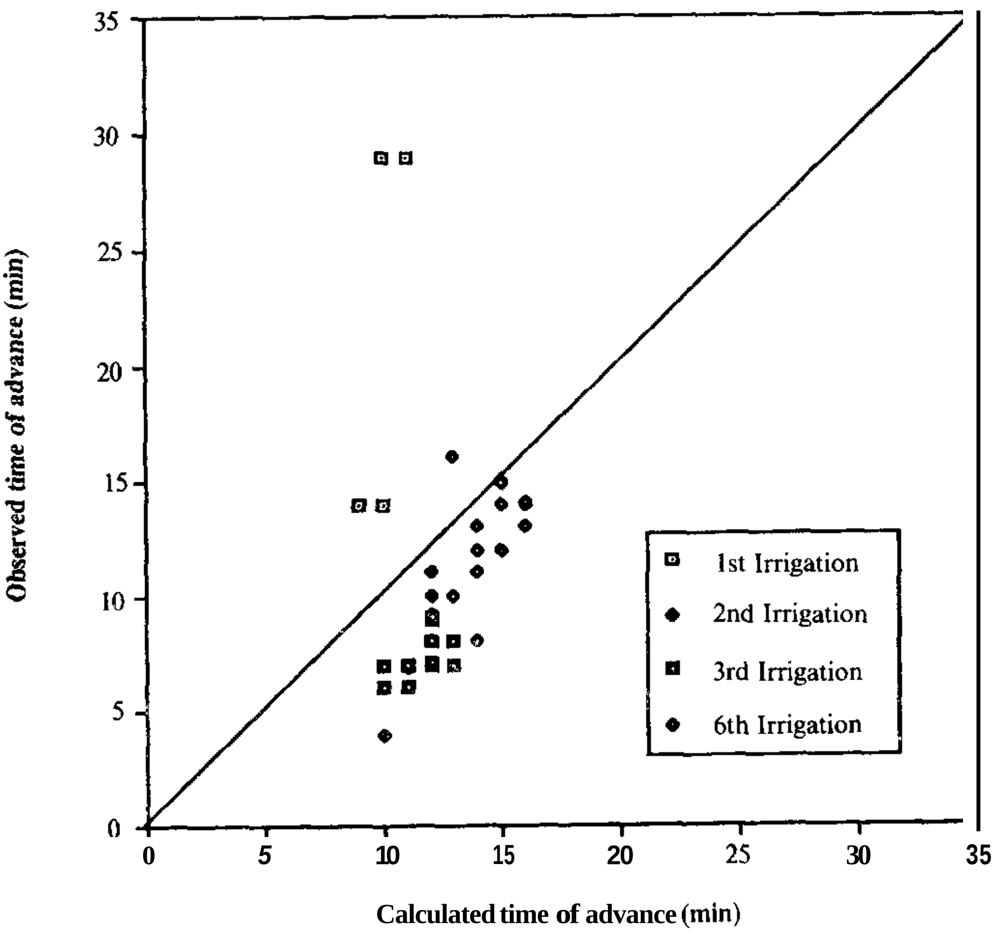

Figure 5. Observed vs. calculated time of advance t_a for field F1.

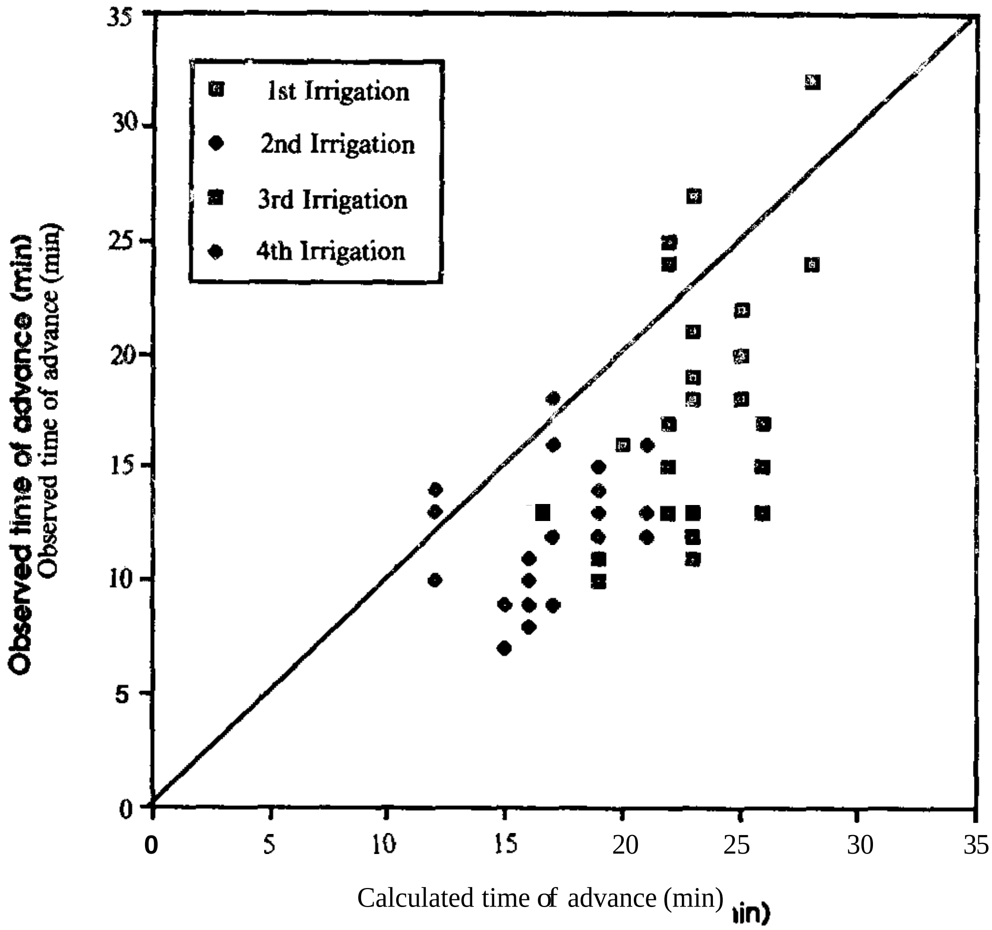

***Figure* 6.** Observed vs calculated time of advance t_a for field F2.

performed better than expected and was probably quiteconservative. Due to the physical problems of the rice soils, however, this conservative approach was necessary. There is a need to conduct agronomic research to determine the extent of relaxing design specifications without sacrificing the performance of the irrigation system and crop yield.

Total water applications and the corresponding yields, as well as other related information are presented in Table 5. Overall water application efficiencies for the entire season were very high in all three fields and resulted in high application uniformities. For **0.330,** 0.325 and **0.379 m** of irrigation water, yields of 8.98, **6.14** and **9.17** t/ha where obtained, while corn yields in fannerfieldsin the area average 2.0-2.5 t/ha. The applied water was very close to the actual plant evapotranspiration water requirements for the growing period and significantly lower than the 0.600-0.800 m of water usually needed for corn production. Using the basin irrigation method, water was applied frequently in small quantities, replenishing an amount' of depleted soil moisture roughly equal to the plant evapotranspiration and never stressing the plants. The farm irrigation system design made possible high yields for small quantities of water while conserving water and energy and limiting the associated costs. The lower yield in F2 was attributed to the heavy soil texture (56% clay) and that rice was grown in adjacent fields. These factors resulted in waterlogging, a very high water table (0.20-0.30 m from the surface) and a shallow root system.

This study addresses the field-level irrigation system design and **was** based on the assumption of complete water control which is the case in shallow privately owned wells. This may not be the case for larger communal or regional irrigation systems.

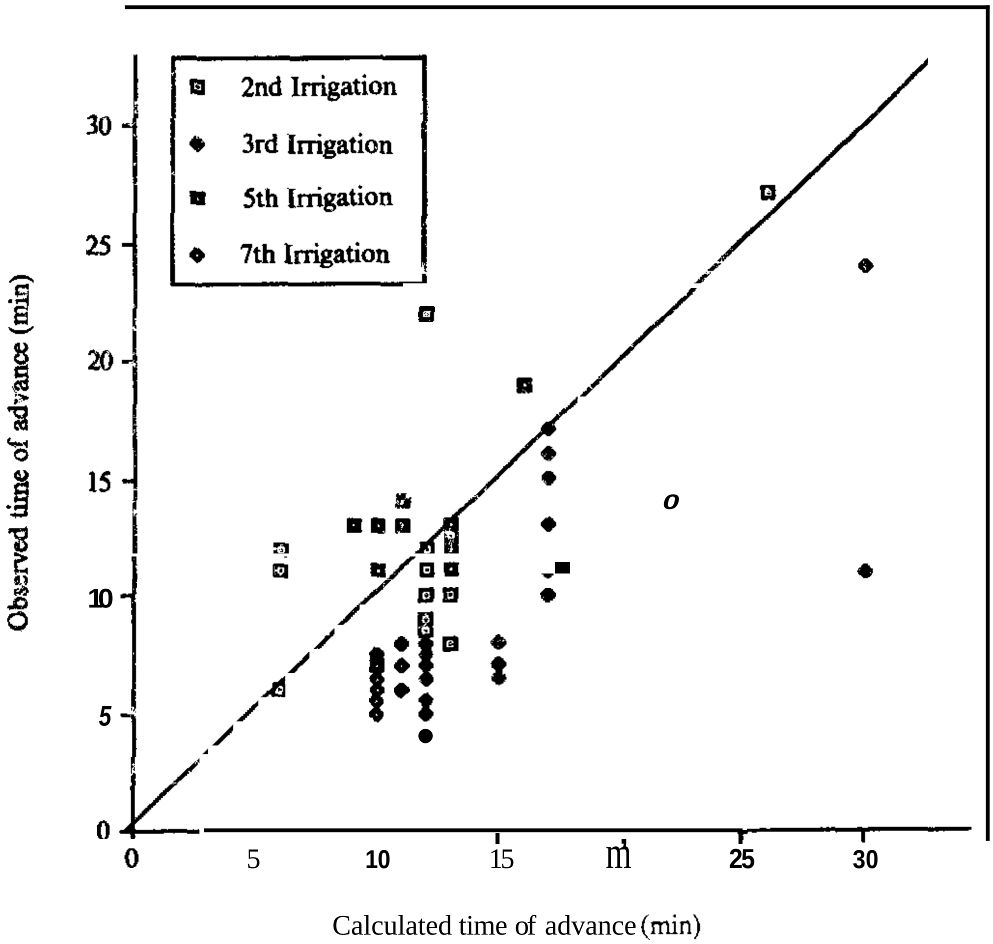

Figure 7. Observed vs. calculated time of advance t_a for **field** F3.

Table 5. Evapotranspiration (ETP), desired and gross applications, overall efficiency and yield in three fields F_1, F_2, F_3.

Field	Total Actual ETP (m)	Desired Total Application (m)	Gross Total Application (m)	Overall Application Efficiency (%)	Yield (t/ha)
F_1	0.284	0.300	0.330	91.1	8.08
F_2	0.309	0.310	0.336	92.4	6.14
F_3	0.327	0.350	0.374	93.1	9.17

Although the same principles of hydraulics apply, the lack of control of water delivery may cause serious irrigation scheduling and operation problems. There is then a need to develop an entirely new large irrigation system management practices in relation with farm level techniques for successful application of basin irrigation method.

The Micro-economics of Crop Diversification in a Diversion Irrigation System: A Progress Report from the UTRIS

Prabhu Pingali, Policarpio Masikat, Piedad Moya and Aida Papag [1]

Abstract

Even if irrigation infrastructure is geared towards rice production, the farmer has several optlons to grow non-rice crops during the dry season. Based on this hypothesis, the study aims to: (1) determine irrigation related constraints to choice of dry season crop at the farm level and examine related farmers' responses, (2) identify changes in water allocation and distribution at the system level in response to changing dry season crop mix, and (3) explore possible means of increasing water use efficiency at the farm level without physical rehabilitation. Thirty sample farmers under the Upper Talavera River Irrigation System (UTRIS) are being intensively monitored for one year. Data being gathered are farm input-output and current and historic issues related to dry season crop choice and decision making. This will be complemented with open ended interviews of the system personnel and officers of the farmer irrigators' association. Preliminary findings of the study revealed that under UTRIS, onion is the main alternative crop to rice during the dry season. Relative to rice, onion requires higher capital and labor and entails higher risk. To alleviate these constraints, farmers have arranged with onion traders for credit and/or resorted to seasonal tenancy arrangements to diffuse price risks and reduce the problem of high labor demand. On the other hand; the efficiency of irrigation water use at the farm level could be increased by: (1) adjusting the schedule and distribution of water to reflect the transition from rice monocropping to diversified agriculture, (2) adjusting irrigation fees to reflect for differences in water use, and (3) adopting ways to conserve water for less frequent applications. It was also observed that there has been changes in the land preferences of fanners in the area and in land values. When the returns to non-rice crop production dominate the returns to rice during the dry season, the demand for and the price of land with the least constraints to diversification out of rice will be the highest.

Introduction

Imgated lowland areas in the Philippines have been experiencing a gradual diversification from rice to non-rice crops during the dry season. The total area planted to dry season non-rice crops may be small but it is significant and increasing. The change in the crop mix has been induced by the declining profitability of dry season rice production systems (Rosegrant, et al., 1987; Ali, 1987). Current discussions on dry season crop choice emphasize the importance of existing irrigation infrastructure as a constraint to diversification (Schuh, et al., 1987; Levine, et al., 1988; Rosegrant, et al., 1987). Many studies have called for rehabilitation of existing irrigation structures in order to increase their flexibility for growing non-rice crops.

This study takes a different approach to the problem of diversification. It focuses on the argument that even if the irrigation infrastructure is geared towards rice production, the farmer has several options available to grow non-rice crops during the dry season. These options involve additional labor investments at the farm level for drainage and water control and tend to be used when the relative profitability of non-rice crop

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production makes these investments viable.

Assuming that farm level adjustments are possible despite system rigidity, then system rehabilitation becomes a software rehabilitation rather than a hardware rehabilitation. In other words, a more appropriate response to the changing dry season crop mix could then be an adjustment in system management rather than in physical structures.

This study aims to: 1) determine irrigation related constraints to dry season crop choices at the farm level, 2) examine how farmers respond to these constraints, 3) identify changes in water allocation and timing rules made at the system level in relation the changing dry season crop mix as well as farmer's requests for change, and 4) explore possible solutions to existing problems in order to increase water use efficiency at the farm level.

System Description

The Upper Talavera River Irrigation System (UTRIS) is a run-of-the-river irrigation system within the Upper Pampanga River Integrated Irrigation System. UTRIS has a potential service area of 3779 hectares, cultivated by 2040 farmers (Table 1). UTRIS consists of 11 laterals and sub-laterals with a total canal length of approximately 60 km (Figure 1). Soil in the system is generally sandy loam except in lateral A which is composed of clay and clay loam; soil in some portion along the main canal turnout is also clay loam. During the wet season, the entire system except for a few hectares, is under rice cultivation (except for farms at the tail end, where year-round green onions are planted since the fields are predominantly gravel).

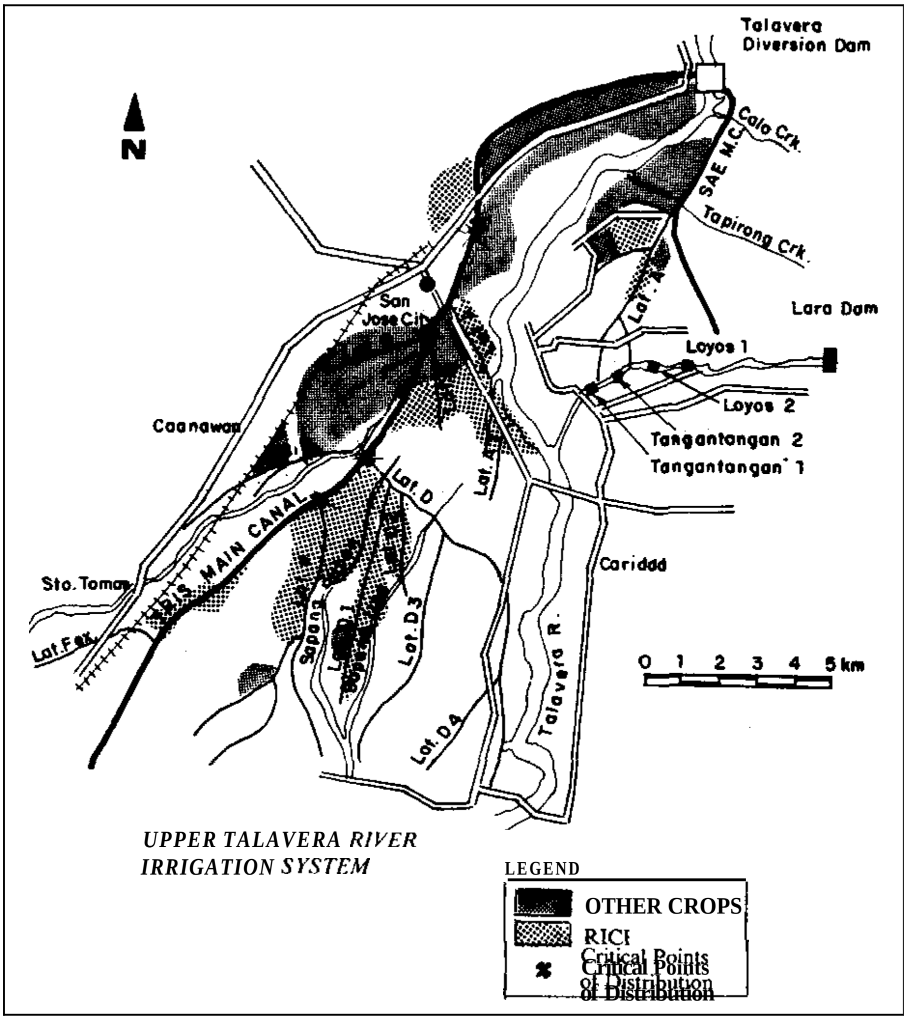

Figure 1. Map of the Upper Talavera River Imgation System (UTRIS) in Nueva Ecija and cropped area for 1987/88 dry season.

Table 1. Basic information, UTRIS.

	TRIS (Main)	San Agustin Extension (SAE)
Service area (ha)	3179	714
No. of farmers	2040	714
Wet season program area*	3632	592
Dry season program area (1988)*	870	242
No. of laterals and sub-laterals	11	3
Total length of canal (km)	60.56	11.42

Source: NIA
*Source: IIMI

During the 1988 dry season, only 870 hectares were irrigated which is roughly 20-25% of the potential service area of UTRIS (Table 2). Lateral A, upper sections of lateral B and turnouts along the main canal were the only areas with reliable water supply during the dry season. Farmers at lateral A grow only rice during the dry season; at lateral R, non-rice crops (onions and peppers), while farmers along the main canal plant rice acd onions. Within UTKIS, 54% of the dry season irrigated area is planted to other crops.

Table 2. Program area and actual area harvested, UTRIS, 1987 and 1988 dry seasons.

	Program area (ha)		Area harvested (ha) Dry season 1987				Area harvested (ha) Dry season 1988			
	DS 87	DS 88	Rice	Other crops	Total area har	Percent area Other crops	Rice	Other crops	Total area har	Percent area Other Crops
TRIS Upper ***(Main)***										
Division B										
TRIS MC	460	500	178	309	437	64	205	275	480	57
Lat B	100	80		100	100	100		92	Y2	100
PAC	40	40	29	14	43	33	37	3	40	8
Division C										
TRIS **MC**	60	100	40	29	60	33	91	13	104	13
Lat A	50	30	50		50		24		24	
Lat C		20					17		17	
Division D										
Lat E	20	15		18	18	100		10	10	100
Lat F	20	50	10	2	11	13	50		50	
MC	15	35	13		13		35		35	
Sub-total	765	870	320	463	782	59	459	393	[illegible]	46
SAE										
'Div A										
SAE **MC**	50	60	10	40	51	19	17	46	62	73
SAE Lat A	100	100	46	69	115	60	31	57	94	61
SAE **Lat A-1**	50	32		35	35	100	2	30	32	93
SAE Lat A-2	50	50	7	15	22	68	19	41	60	68
Sub-total	250	242	64	158	222	71	14	174	248	70
Grand total	1015	1112	384	621	1004	62	533	567	1100	52

Source: IIMI

Waterallocutiondecisionmaking. Scheduling and allocation of water is facilitated by water-masters in consultation with the zone engineer and hydrologist. The irrigators' associations decide on water allocation at the lateral or turnout level. These associations decide on the scheduling of water to the individual turnouts within their lateral. An organizational chart is provided as figure 2. The figure also shows the division of decision making responsibilities.

The following biases in water allocation rules persists at the system level: a) water is allocated based on the water requirements of rice even during the dry season and for laterals known to grow exclusively non-rice crops, and b) preference is given to upstream farmers on the pretext that conveyance losses are minimized and output maximized. The above biases lead to the following implications: a) farmers who plant non-rice crops during the dry season have to invest in farm level water control to suit the requirements of their crops, and b) farmers whose farms are located farther away from the source of irrigation water have to invest in supplementary irrigation (shallow well pumps) to meet dry season water requirements.

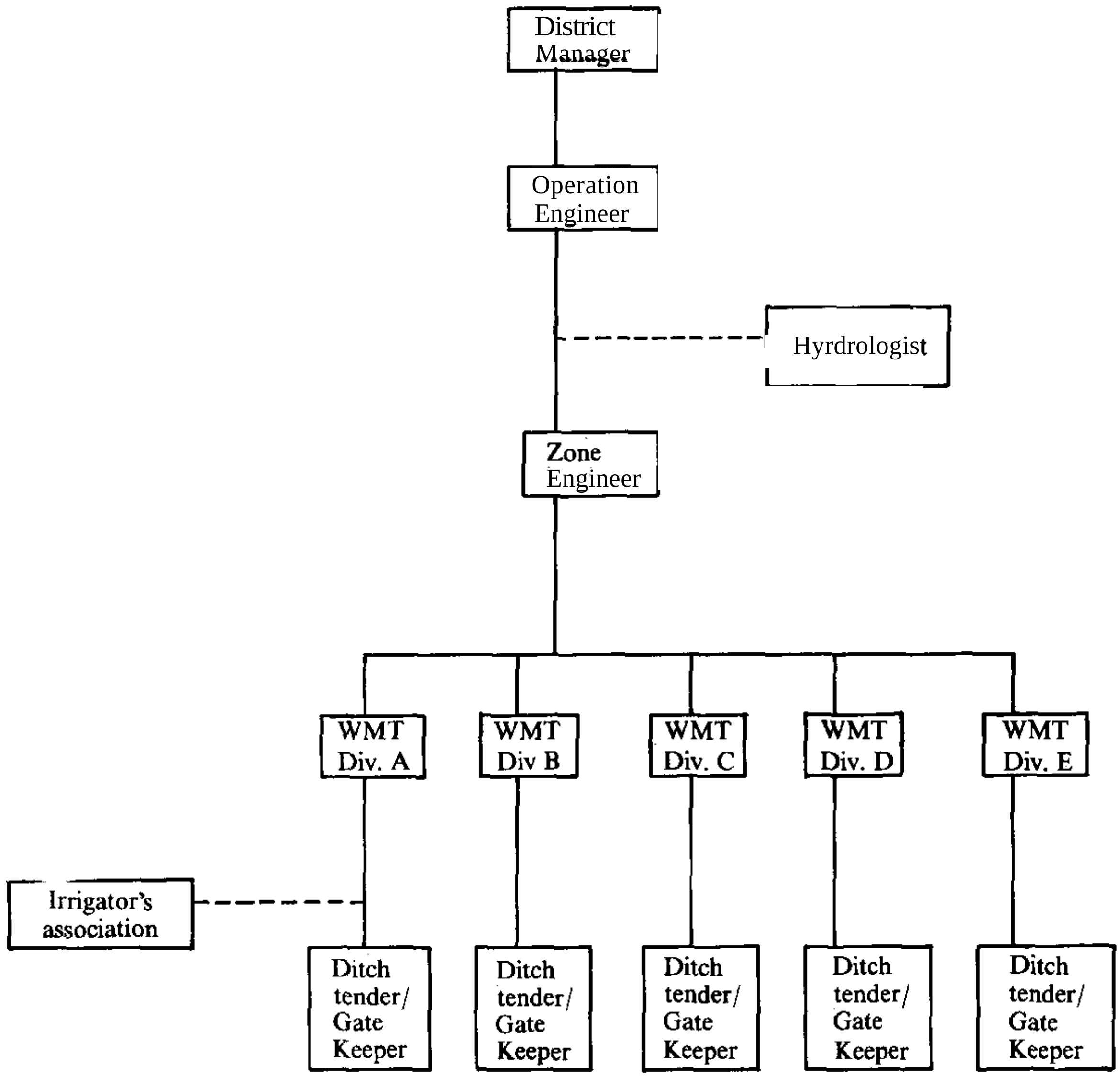

Figure 2. Organization chart, UTRIS.

Irrigation fees. There is a uniform irrigation fee for all farmers in the system, whether they are located at the head, middle or tail and whether they are near or far from the irrigation canals. Fees do not vary even if a farmer irrigates his crop a number of times. However, there are differences in irrigation fees depending on the season and crop. For wet season rice crop, the fee is 125 kg of paddy per hectare or its peso value. During the dry season, irrigation fee for rice is 175kg of paddy per hectare. For non-rice crops, fees are 60% of the fee charged for rice.

income information were being monitored. It was planned to monitor for a year to be able to get a complete picture of the alternative income earning opportunities available to the farmers, considering the crop and agricultural versus non-agricultural activities.

This intensive monitoring will be accomplished by frequent visits to the farmers. Open ended questions on current and historic issues related to dry season crop choice decision making were being asked from the farmers with the help of the system management (zone engineer, hydrologist, watermasters and ditchtenders) and the management of the irrigators' associations at each lateral and turnout. The objective of the management related interviews is to study the flow of information from the system management to the farmers and vice-versa.

Table 3. Characteristics of the samples being studied.

Characteristics	Lateral A	Lateral B	MCs
Number of farmers	7	11	12
Number of parcels	8	15	22
Distance from irrigation canal			
- near	4	6	8
- far	3	5	4
Cropping pattern			
-- rice-rice	6		2
-- rice-onion	1	8	5
- rice-onion+vegetable		3	2
-- rice-rice+onion			3
Soil type			
-- galas		11	6
-- lagkit	6		4
- mestizo lagkit	1		2
Dry season water stress			
-yes	7	10	8
- no		1	4

Sample Selection and Characteristics

A stratified random sample of 30 farmers were selected from the head, middle and tail sections of UTRIS. The sample was also stratified between farmers whose paddies are near to or far from the irrigation canals. Within each lateral, the sample was also stratified by major soil type. Farmer classification of soils were used for this stratification, namely Galas (sandy loam), *Lagkit* (clay) and Mestizo *Lagkit* (clay loam). Table 3 describes the stratifed sample.

For each parcel, weekly input-output, technology, investment, crop choice, labor use and

There is a distinct soil type bias in cropping patterns (Table 4). Farmers tend to grow rice only during both seasons in the heavier clay soil. Most farms with sandy loam soil are planted to onion during the dry season. However, five parcels with clay and clay loam soil were planted to rice. These parcels were being closely monitored.

Table 4. Dry season cropping pattern by parcel and soil type.

Soil Tvpe	Rice	Onion	Others
Galas (sandy loam)	4	20	4
Lagkit (clay)	10	3	
Mestizo Lagkit (clay loam)	2	2	

The relative input requirements and the relative returns to rice and onion production are shown in Table 5. On a per hectare basis, onions required thrice the financial outlay of rice while net returns were at least five times as large. However, the average area planted to onions was about 0.5 hectare and that to rice was about 1.5 hectares. The net returns per average area planted to rice and onions are ₱10,413 and ₱26,498 respectively. Table 6 and 7 shows the labor input requirements for onions and rice. Onion production is three to four times more labor intensive than rice.

Table 5. Relative cost and returns to rice and onion production.

	Rice	Onion
Inputs @'/ha)		
Seeds	644	6,087
Fertilizer	1,150	2,471
Insecticide	352	715
Herbicide	81	262
Rice straw		142
Labor cost	3,743	7,630
Irrigation fees	612	367
Total Inputs (₱/ha)	6,581	17,674
Average yield (t/ha)	3,967	9,063
Gross income (₱/ha)	13,863	71,751
Net income @'/ha)	7,282	54,077
Average area harvested (ha)	1.43	0.49
Net income per average harvested area (₱)	10,413	26,498

Note: Land rent will he included as more accurate data become available.

Table 6. Labor inputs per hectare for onion during the drv season

Activities	Man-davs	Total cost	
Land preparation			
Plowing			
machine	0.9	550	852
animal	6.0	302	
Harrowing			
machine	1.1	515	853
animal	6.8	338	
Seedbed preparation/seeding	10.3	206	
Pulling seedlings	30.0	600	
Transplanting	80.0	1600	
Mulching	16.0	320	
Application of fertilizer	4.3	86	
Application of insecticide	5.1	102	
Weed control			
manual	61.6	1232	
chemical	1.3	25	
Irrigation management	11.3	225	
Harvesting, bundling, drying	88.5	1170	
Total	323.2	7270	

Table 7. Labor inputs per hectare for rice during the dry season.

Activities	Man-days	Total cost
Land preparation		
Plowing *and harrowing*		
machine	5.1	1028 } 1440
animal	8.3	412
Seedbed preparation	1.6	40
Pulling of seedlings*	0.4	105
Transplanting/direct seeding	17.6	353
Application of fertilizer	1.6	33
Pest and disease control	2.2	45
Weed control		
manual	4.0	80
chemical	0.7	15
Irrigation management	12.2	244
Harvesting	21.0	420
Threshing		
manual		
thresher.'	2.0	819
Haulina	3.5	150
Total	80.4	3743

Note: *By pakyaw contract

**Sharing is 6% of gross value of production.

Preliminary Results

The following are some of the initial findings of the study; The findings are extremely tentative and will be substantiated with rigorous empirical evidence as data become available. This paper should therefore be considered a progress report designed to stimulate discussion.

Dynamics of Farmer Land Preferences

Over the last five years, changes in the preferences for dry season land cultivation and consequently in land values has been observed at UTRIS. UTRIS consists of areas with heavy clay soil (lateral **A),** areas with sandy loam soil and a small area with very stony soil (lateral **B).** During the last five years, land preferences have switched from the heavy clay **soils** to the sandy loam **soils.**

Within an irrigated micro-environment, the lands with the greatest preference for rice production are those with heavy clay soils and those that have the best access to irrigation water (lands in the head section and paddies close to irrigation canals). The unit cost of rice production would be the lowest on these lands as compared to paddies at the tail section, those far from the irrigation canals and those with more sandy soils. **As** long as the returns to rice production dominate all alternative crops within the system, the demand for and the price of these lands will be higher than in other areas of the system.

As the relative returns to dry season non-rice crops increases, preference for lands normally considered marginal for rice production increases. In irrigated lowlands, the following could be considered marginal to dry season rice production: upper paddies that are difficult to irrigate, well drained soils, sloping lands, and stony gravelly land. These lands are more suitable for dry season non-rice crop production due to their good drainage characteristics. Investment requirements for drainage are lower on these lands as compared to: low lying paddies, heavy clay soils and land with better access to irrigation water.

The following generalization is possible: In irrigated lowlands, when the dry season returns to non-rice crop production dominate the returns to rice production, the demand for and the price of land with the least constraints to diversification out of rice will be the highest. Under UTRIS, lateral **A** had aconcentration of heavy clay soil and therefore is most constrained to diversify out of rice production. Areas at lateral B and at the main canal turnout have several options for dry season crop production, including rice. During the last five years the returns to dry season onion production dominated the returns to rice production. **A** change in land demand from lateral **A** to other parts of the system was also noted. Land values at lateral **A** which were once the highest under UTRIS are now dominated by lateral B.

Results, however, do not imply that lands at lateral A are not suitable for non-rice production. Other areas with similar soil and hydrological characteristics may have diversified out of dry season rice production. The study emphasizes that investment **costs** for drainage required for making the switch to non-rice crops would be substantially higher at lateral A than at other laterals of the system and would not be viable given the current returns to rice relative to the best alternative possible. In other words, there is a price at which it becomesviable to make investments in overcoming the agronomic and hydrologic constraints to diversification.

Credit, Labor and Risk *Constraints* to Crop *Diversification*

Under UTRIS, the main alternative to dry season rice production is onions. Relative to rice, onions require more fmancial outlay for inputs (Table 5), more labor and supervision (Table 6), and more effort to diffuse the impact of price risks. Several ways in which farmers had overcome these constraints in their switch from rice to onions were identified.

Constraint in credit in onion production had been alleviated by arrangements with onion traders. Onion traders from San Jose City provided credit for the purchase of inputs in exchange for a commitment from the farmer that they have the exclusive right to purchase all output at the market price at harvest time. No interest is charged for this credit, but the traders benefit substantially from the substantial price increase between the harvest and post-harvest months. This price increase more than offsets the foregone interest charges and the storage costs.

Relative to rice, the per hectare labor requirements for onions were substantially higher. Planting, weeding, harvesting and post-harvest operations in onion production were labor intensive. **Also,** farmer supervision of farm operations was significantly higher for onions. Supervision time rather than the higher labor requirements were the dominant labor constraint in onion production. This is due to the highly inelastic nature of management labor available in the farm household, while hired labor supply being augmented by seasonal migrants is relatively more elastic. In order to overcome the supervision constraint, several of the larger onion producers with farms greater than two hectares divided their farms into two -cultivating **one** part and providing the other part to seasonal tenant farmers. Seasonal tenant farmers either come from lateral **A** or from neighboring areas to cultivate onions during the dry season. These farmers till the land and provide one-half of the farm inputs in exchange for **50%** of the total production.

Seasonal tenancy arrangements could also be a method of diffusing price risks associated with onion production. The means by which the smaller onion growers do this is to divide their farms into two - cultivate one part and give the other to a seasonal tenant who pays a fixed rent of ₱3000 per hectare plus water charges. In this way, the landowner gets a certain income from part of his land and gambles on the remainder. The supply of seasonal tenants has been increasing over the last few years especially from lateral A and similar lands with agronomic constraints to diversification.

Efficiency of Warer *Use* ***for*** Non-rice ***Crop*** Production

Two factors affect the efficiency of irrigation water use under UTRIS. These are the system of charging irrigation fees and the distribution scheduling and timing of water supply.

Considering these systems, upstream (head and upper middle section) farmers and those nearer to irrigation canals do not have an incentive to alter their water use practices to increase efficiency. The traditional irrigation technique for these farmers is to flood and drain their fields.

Table 8 shows the frequency ***of*** irrigation by location along the system and distance from the canals. In this table MCs stand for main canal turnouts and B is lateral B. The MCs are at the upper section of the system than **B.** In general, farmers in the MCs applied water more frequently than farmers in B. Over **50%** of the sample in the MCs used more than five irrigation which is higher than the highest number of irrigation in B. The highest number of irrigation in MCs is **12.** Within a lateral, farmers near to the canal used more irrigations than farmers far from the canal (Table 8).

Table 8. Dry Seasons Onions: Frequency of irrigation by distance from irrication canals.

Lateral	Distance from irrigation canal	Frequency of irrigations														
		I	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**	**0**	**1**	**1**	**1**	**2**
B	Near	**1**	**1**	**1**		**2**	**1**									
	Far	*3*				1	*1*									
MCs	Near					1	1				**1**	**1**		1	1	
	Far		1			1				1						

The above also implies that farmers at the lower sections of the irrigation system and those farther away from irrigation canals ought to be more efficient in their water use. Water supply **is** not reliable for these farmers and even if they do get the water, the quantity available to them per hectare **is** only a fraction of that available to the more favorably located farmers. These farmers do not have a choice except to conserve water at the maximum to enable them to grow onions. Thus, farmers at the outer (less favorable) sections subsidize the water use of farmers in the inner (more favorable) sections of the system.

Farmers at the outer sections (tail and far paddies), availed of supplementary irrigation from shallow well pumps. Table 9 shows the frequency of supplementary irrigation use by distance from the irrigation canal. Two-thirds of the near parcels in lateral Bused exclusively canal water while only one-fifth of the far parcels used exclusively canal water.

Table9. Frequency of supplementary irrigation using pumps at Lateral **B.**

Distance from canal	Frequency **of** irrigations					
	0	I	2	3	4	5
Near	**4**	-	**2**	-		
Far	I		1	**1**	2	-

It was, however, surprising to find that farmers near the irrigation canals were the most delinquent payers of irrigation fees (Table 10). Farmers whose farms are located far from the lateral had to pay their fees promptly to ensure timely and adequate water supply while farmers whose farms are close to water source could acquire water even if they do not pay their fees. Farmers far from the canals therefore, bear the burden of irrigation costs while at the same time receive lesser benefits from the system.

Table 10. Payment of irrigation fees.

Lateral	Distance	Paid	Not paid
A	Near	I	**2**
	Far	**2**	2
B	Near	**2**	**4**
	Far	**3**	2
MC	Near	*3*	**5**
	Far	13	I
		14	16

In order to increase the farm level efficiency of water use at the head and in adjacent fields, three conditions are required: 1) irrigation fees have to be based on the number of applications rather than on a fixed rate, 2) water scheduling and supply for areas planted to non-rice crops has to be different from areas planted to rice, and 3) more involvement of irrigators' associations in monitoring water use and fee collection. If water in the upper sections of the system can be used more efficiently, then the total area for which water is available will increase significantly resulting in increase in income and equity.

Efficiency Increases versus System Rehabilitation

Should the priority of irrigation management be in making investments in system rehabilitation or in increasing the efficiency of water use?

Under UTRIS, the above discussions imply that significant increases in actual irrigated area could be achieved by improving the efficiency of water use at the upper and in more favorably located sections of the system. Can significantly greater income gains be achieved by system rehabilitation to warrant greater investment? This question has to be examined in detail.

Improving the efficiency of water use would require adjustments at system and farm levels. At the system level, this would imply changes in water scheduling and rules of allocation to reflect the shift from rice monocropping to diversified agriculture. Irrigation fees have to be revised to account for differences in water use rather than a fixed rate for water use (Ghate, 1987 provides a review of the different structures of irrigation fees and the system and farm level benefits of each). At the farm level, efficiency increases could be achieved by adopting ways to conserve water. Mulching is one way to conserve water in onion production.

Demand for Membership in Irrigation Association

More farmers are expected to join the irrigators' association if the benefits they receive would exceed cost of membership which are monetary (membership fees and annual dues) and non-monetary (time spent in association activities, etc). The benefits of belonging to an irrigators' association are high when collective action is needed and when collective action is feasible, Collective action is needed to: a) ensure adequate water supply, b) regulate timing of water supply, and c) prevent the flow of excess water into the non-rice crops.

Consider the cases of laterals A and B under UTRIS: lateral B has a well organized irrigators' association, while at lateral A, attempts to organize an association failed. The reason for failure at lateral A was because of its being located at the upper portion of the system; thus, farmers had adequate water supply during the dry season. Moreover the entire lateral is planted to rice, hence there is minimal need for in-season regulation of timing because farmers do not encounter problems of having too much water in the field. Farmers at lateral B, grow only onions during the dry season. Timing of water supply is different for onions than for rice and in-season regulation of timing of water supply is important. Water has to be regulated to prevent excess in the onion fields; hence, the need for a collective action in B which attributed to the success of irrigators' association.

Collective action, although desirable may not always be feasible like the group of fanners at the tail end of lateral B. These farmers organized themselves into an irrigators' association but their efforts to increase their water allocation were futile. There was not enough water during the dry season. After two years these farmers ceased paying their membership fees and relied on pumps for their water needs.

The following generalization may be possible: the benefits of joining an irrigators' association are high if the farm is favorably located and where farm level decisions on timing of irrigation need to be made (otherwise costs exceed benefits).

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Successful Crop Diversification in Irrigated Rice Farms: Development of a Cognitive Decision Making Model

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Abstract

Six groups (cases) of farmers involved in crop diversification after rice were studied to determine the economic and institutional factors behind the successful adoption and continued cultivation of crops other than rice. Some *266* farmers were interviewed. The crops they cultivated were: tobacco, cotton, tomato, onion, mungbean, garlic, corn and peanut. All of the farmers were from Central and Northern Luzon, Philippines.

The decision making process **was** modeled using Gladwin's **(1983)** method. Several conditions conducive to crop diversification were obtained from the interviews. Among these were: low income from other sources, profitability **as** seen from other farmers, sufficient rice supply for one's own consumption, availability of seeds, insufficient water supply for rice, experience, perception of high market prices for the crop, presence of technical and institutional support. While a decision-making model could be developed, testing is required on a separate validating sample.

Introduction

Successful crop diversification in irrigated rice lands refers to the situation where farmers in an irrigated area regularly grow one or more non-rice crops during the dry season.

Traditionally, the existence of irrigation in the Philippines has meant two or more croppings of rice monoculture per year. Crop diversification in irrigated farms is the exception rather than the rule in spite of the fact that the profitability of rice farming has not increased proportionately with the increase in rice yield.

Crop diversification is important for achieving stable **food** supplies in the country and **for** earning and/or saving foreign exchange. It is also one **of** the means for increasing farmers' incomes. Hence, the impetus toward irrigated crop diversification. Given this impetus, and given that irrigated crop diversification is relatively new, there is a need to examine areas where irrigated crop diversification **is** being successfully practiced.

Objectives

The study aimed to examine and document six cases of successful crop diversification in irrigated rice lands focusing on the economic and institutional as well as the physical and technical factors that have been supportive to crop diversification.

The six cases examined were: tobacco farming in San Fabian, Pangasinan; cotton farming in Urdaneta and Manaoag, Pangasinan; tomato farming in Sta.Barbara and Mapandan, Pangasinan; mungbean farming in Manaoag and Urdaneta, Pangasinan; onion farming in San Jose, Nueva Ecija; and garlic, corn and peanut farming in Laoag, Ilocos Norte.

A total of **266** farmers were interviewed: 40 tobacco farmers, 40 cotton farmers, **40** tomato farmers, **40** mungbean farmers, **40** onion farmers and 66 garlic/corn/peanut farmers.

A major component **of** the research **was** an attempt to model the cropping decision making of

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the farmers vis-a-vis diversified crops. The model used in this study was a modified version of Gladwin's[2] decision tree model (Figure 1).

The model posited three stages in the cropping decision:

Stage 1 consists of assuring the family's rice consumption requirements. It is hypothesized that a risk-averse farmer will first make **sure** that food for his family, i.e., rice, will not be compromised **by** planting other crops.

If this **is** satisfied, the farmer then considers the technical **(soil,** topography, water, timing, knowledge) and economic (demand, time, labor, capital, credit) feasibility of planting the diversified crop. **This** constitutes Stage **2.**

If the crop satisfies the technical and economic feasibility requirements, its potential costs and returns (i.e., profitability) **is** then considered (Stage **3).** A decision to plant the diversified crop will' be made if the profitability of the crop is perceived as equal to or greater than the minimum profitability over the traditional crop (rice) for which the farmer is willing to take the risk of planting the diversified crop. The model was tested in each of the six cases.

The Six Cases

Five of the six case studies were in Region I or Northern Luzon (four in the province of Pangasinan and one in Ilocos Norte); the Nueva Ecija case **is** in Region III or Central Luzon. Two of the cases — tomato and cotton — involve contract growing schemes; the farmers grow the crops on their own in the other four cases.

With the exception of the tomato and cotton farmers, other farmers have had long experience in planting diversified crops: the average number of years of growing the crop was 22 years for tobacco farmers, 18 years for mungbean farmers, 21 years for onion farmers, 16 years for garlic farmers, 15 years for corn farmers and 16 years for peanut farmers. Although the tomato farmers had been growing native tomatoes for many years (an average of over 10 years), they started planting the imported variety only in the last one to three years **as** part of the contract growing scheme. The cotton farmers have been planting cotton for an average of only two years.

Tohocco Farmers

The tobacco farmers of San Fabian, Pangasinan planted burley tobacco. The Philippine Virginia Tobacco Administration (PVTA) office in Pangasinan oversees the burley production in San Fabian. Aside from extension services, the PVTA also assists farmers in marketing their produce by supervising licensed traders. PVTA also sponsors the "Outstanding Burley Tobacco Grower of the Year" award.

Most of the tobacco farmers planted only rice during the wet season and only burley during the dry season. Over the years, tobacco growing has been a profitable venture for the farmers — the average ratio of the number of years of positive net to the total number of years the farmers have been planting tobacco was **0.92.** During the 1985/86 dry season, the average net retums above cash costs per hectare of burley was **3.48** times the wet season rice crop.

The major buyer/trader of burley tobacco leaves in San Fabian was a Chinese middleman who **also** acts as an informal money and input lender to the farmers. He loaned the farmers money at 6% interest rate per cropping season. The input loans had no stipulated interest rates but their prices were marked-up to include interest costs.

Cotton Formers

The cotton farmers of Urdaneta and Manaoag, Pangasinan were contract growers for the Philippine Cotton Corporation (PCC), a government-controlled corporation. PCC takes charge of undertaking and implementing the commercial production of cotton in the Philippines. PCC technicians regularly visit farmers to convince them to plant cotton. In the contract growing scheme, PCC provides the farmers with technical advice and inputs – seeds for free and fertilizer chemicals and cash loans without interest but the payment of which are deducted from the gross sales. PCC sets the purchase price of cotton before the cropping season. During the 1985/86 dry season, price of cotton was ₱8.00/kg.

Although rice was the predominant wet season crop and cotton was the predominant dry

[2]**Gladwin, C.H. Contribution of decision-tree methodology to a farming systems program.** ***Human organization,*** **Vol. 42, No. 2, 1983, pp. 146-157.**

Figure *1.* A Descriptive Model of Cropping Decision Making.

Stage 1. Satisfaction of Basic Needs: Assuring rice consumption requirements

Q: Will the family's rice consumption requirements be set if the farmer plants other crop(s)?

↓

YES (Move on to Stage 2)

NO Is (are) there non-rice crop(s) with possible returns that will allow the family to meet its rice consumption requirements?

↓

- **YES** (Move on to Stage 2)
- **NO** (Plant rice only)

Stage 2. Testing for Feasibility: Satisfaction of technical constraints and economic feasibility[1]

Technical Constraints:

- soil, topography
  (Does crop X yield well at farmer's soil, topography?) → if no → eliminate crop X
- water requirements
  (Does farmer have irrigation or is the water enough to meet the requirements of crop X?) → if no → eliminate crop X
- timing of farm operations
  (Is the timing of farm operations for crop X acceptable to the farmer?) → if no → eliminate crop X
- knowledge
  (Does farmer know how to plant crop X or will he able to obtain information?) → if no → eliminate crop X

Economir Feasibility:

- Demand
  (Can the farmer sell crop X in a nearby market or to a merchant?) → if no → eliminate crop X
- Time. labor
  (Does the farmer have the available time and accessible labor to help him plant crop X?) → if no → eliminate crop X
- Capital, Credit
  (Does the farmer have the capital or accessible credit to buy inputs for crop X?) → if no → eliminate crop X

Stage 3. Cost-Benefit Analyses

Examination of the expected returns of each alternative crop vis-a-vis costs.

Q: Is returns from crop X n[2] times greater than returns from previous crop (rice)?

↓

- **YES** Plant crop X
- **NO** Stick to old crop (rice)

[1] There is no particular sequence in which the farmer processes each alternative crop vis-a-vis the technical constraints and economic feasibility. Suffice it to say that any alternative crop that fails to meet any one of the above-mentioned four technical constraints or three economic feasibility requirements is eliminated from consideration.

[2] n is a value which represents the minimum profitability of crop X over the previous crop for which the farmer will be willing to take risk of planting crop X. n is an empirical value that is greater than 1

season crop of the cotton farmers, many of them planted other diversified crops (i.e., corn, mungbean, tomato, and stringbeans) during the wet and dry seasons.

Cotton growing has been financially rewarding for the farmers: since they began planting cotton, the farmers realized positive net returns from their cotton crop 90 percent of the time. Furthermore, they reported hitting the ***jackpot*** with their crop from one-third to one-half of the time. During the 1985/86 dry season, the net returns above cash costs of cotton was 2.58 times greater than the previous wet season rice crop.

Tomato Growers

The tomato farmers of Sta.Barbara and Mapandan Pangasinan were **also** contract growers of the Philippine Fruit and Vegetable Industries, Inc. (PFVII). Contract growing of tomatoes was introduced in the area during the 1983/84 dry season. Under the contract growing scheme, PFVII provides the farmers with technical assistance and credit in the form of seeds, fertilizer, chemicals and cash at an interest rate of 1.5% per month. PFVII buys the produce at a price that it sets before the cropping season. During the 1985/86 dry season, price for tomatoes was ₱0.80/kg.

The farmers planted California variety tomatoes during the 1985/86 dry season. Farmers were given the expectation by the PFVll technicians that the California variety has a potential yield of 40 t/ha. Majority of the farmers also planted other diversified crops in addition to the contract-grown tomatoes during the 1985/86 dry season (e.g., native tomatoes, mungbean, corn, eggplant, gourd, beans, and sugarcane).

The farmers have been growing native tomatoes for an average of over 10 years. Over the years, the native tomato crop has given the farmers good returns: the farmers had positive net returns from their tomato crop 84 percent **of** the time and hit the ***jackpot 20*** percent of the time.

However, farmers who planted the California variety during the 1985/86 dry season incurred losses. Of the projected harvest **of** 40 t/ha, actual yield obtained was 7.7 t/ha which was only 19.4 percent of the PFVII estimates. The low yield was aggravated by the farmers' high fertilizer and chemical usage, the low purchase price set by PFVII, and the failure of PFVll technicians to get the harvested tomato on time from a number of farmers resulting in the rotting of the produce. (This happened after the 1986 snap presidential election and the February Revolution). **As** a consequence, many farmers owed PFVll money at the end of the cropping season because the **gross** sales were not enough to pay for the input loans. Considering the **poor** performance, PFVII decided to discontinue its contract growing scheme in the area. Most of the farmers indicated, though, that they will continue planting the native variety.

Mungbean Farmers

Mungbean has been the traditionaldry season crop of farmers located at the border of Manaoag and Urdaneta, Pangasinan. Inadequate irrigation water for rice or other crops during the dry season was a major reason for the widespread cultivation of mungbean. Considering this situation, the National Irrigation Administration **(NIA)** office in Urdaneta, Pangasinan has been programming the area for mungbean production. During the 1985/86 dry season, over **250** hectares were programmed by NIA for mungbean production.

Mungbean production in Manaoag and Urdaneta was characterized **as** using low labor and input. Mostfarmersdid not plowtheirfieldsbefore planting. Instead they simply broadcasted the seeds into the field containing the rice stalks, then the field was harrowed. After emergence, little else was done except for the weekly spraying of pesticides. Fertilizers were not applied nor was weeding practiced.

The farmers have been planting mungbean for an average of 18 years. Over the years, farmers have consistently realized net profits from their mungbean crop (the ratio of number of years of positive net returns to total number of years of plantingthecrop was0.91). Rarelydid farmers'hit the "jackpot" with their mungbean harvest.

Unlike other diversified crops covered in this study, mungbean had much lower cash and non-cash costs than rice. Despite this and the relatively high mungbean price (during 1985/86 dry season price of mungbean was **PI1.00/kg),** production was less profitable than rice. Many of the farmers incurred losses from their mungbean crop during 1985/86 dry season. Two reasons explain such losses: very low yields which averaged **0.385** t/ha were obtained due to poor cultural practices employed and high pesticide input which cost ***52*** percent of the cash returns from the harvest.

The farmers themselves marketed their mungbean harvest. The produce was brought to the Urdaneta Public Market by tricycle and was directly sold to the traders/grain dealers or stall owners.

Onion Farmers

The onion farmers came from San Jose City, Nueva Ecija. The area is known as one of the largest producers of onions during the dry season. The farmers have been regularly growing onions after the wet season rice crop for an average of 21 years.

Farmers in San Jose plant four onion varieties: ***Batanes*** and ***Tanduyong*** which are native red onions and the hybrids ***Red Creole*** and ***Yellow Granex.*** The native varieties, which have been planted more extensively command a higher price and can be stored longer than the hybrids.

Farmers sold their produce to individual traders who in turn sold the onion purchased to trading centers in San Jose City. Trading centers sold the onions in large quantities to owners of storage facilities who were the major buyers. Storage facilities were located in Bongabon and Palayan City, Nueva Ecija.

Over the years, the fanners' onion crop has fared quite well. Farmers realized positive net returns from their harvests **87** percent of the time. The average jackpot ratio was 0.18 which indicated that on the average, farmers hit a ***jackpor*** once in every five cropping seasons. The 1985/86 dry season was considered **as** one of the 'jackpot" years when farmers realized an average net returns above cash costs, 4.7 times greater than the preceding wet season rice crop.

Garlic Farmers

Farmers in Laoag, Ilocos Norte have been traditionally growing diversified crops during the dry season. Garlic was the major diversified crop grown; other crops grown were corn, peanut, mungbean, watermelon, and vegetables like cabbage and eggplant. Farmers who planted garlic, corn and peanut or a combination of these crops were interviewed. Of the 66 farmers interviewed, 60 have been planting garlic during the dry season for an average of 16 years; 40 have been planting corn for an average of 15 years; and **46** have been planting peanut for an average of 16 years. All farmers have consistently realized positive net returns from their harvests: 90 percent of the time for garlic, 96 percent of the time for corn, and **97** percent of the time for peanut. The crops, however, yielded few "jackpots" — with ratios ranging from 0.10 to **0.14** only.

Price of the 1985/86 dry season garlic crop was quite low at ₱13/kg. Most farmers opted not to sell their produce until a higher market price was reached. **As** of the interview date in April and May 1986, only 35 percent of the garlic farmers had sold their produce. The farmers blamed the low market price to illegal and clandestine importation or smuggling of garlic in large quantities from Taiwan. Nevertheless, many farmers expressed optimism that the price would soon increase and that they would he able to sell their produce at **a** satisfactory price.

Positive net returns above cash costs per hectare were obtained from corn and peanut during the 1985/86 dry season. These were higher than the net returns above cash cost of the previous wet season rice crop.

Farmers sold their garlic, corn and **peanut** to traders and stall owners at the Laoag City public market. Although a number of the farmers used some of their corn harvest for animal feed, the corn was sold in the market for human consumption.

Factors Influencing Adoption

Analysis of the six case studies revealed the conditions that **were** conducive to the adoption and persistence of irrigated crop diversification during the dry season. The analysis also revealed problems that reduce the viability of crop diversification which need to be addressed.

Lack of sufficient irrigation water for rice during the dry season prompted farmers to diversify. However, once a crop proves profitable, even if there was sufficient irrigation water, farmers persisted to plant the diversified crop.

A lower income obtained from other sources appeared to relate positively to a greater tendency for farmers to diversify during the dry season. A plausible reason for this is: the smaller one's income from other sources is, the greater is the need to maximize the returns from one's farm as well **as** to spread one's risks. This twin objectives can be best obtained by planting more than one crop during the dry season.

Results indicate that, the smaller the farm size and the fewer the parcels farmed, the greater tendency was for farmers to plant the diversified crop only (and not rice also) during the dry season. This can be explained by the fact that rice cultivation is not profitable if the area planted is very small.

The datashowed that the farmers were willing to face more risks in crop diversification provided that the crop was perceived as profitable, especially if they have witnessed other farmers' successful experiences, and provided that there was no better alternative crop. Provision of technical assistance, credit for inputs, and marketing mechanisms also enticed farmers to diversify.

The persistence of crop diversification was related to a trend of positive net returns punctuated by occasional "jackpots". As the ability to tolerate a negative net return increased, the longer was the history of positive nets. Thus, long-run averages have influenced the persistence of crop diversification.

Hitting the jackpot was attributed to: (1) high yields due to proper cultural and management practices and (2) high prices. Results suggest that fanners perceived high returns due to their own efforts and not from the vagaries of price fluctuations. Results also indicate a strong sense of personal control which was opposite to the usual notion of fatalism which was often ascribed to farmers. Indeed, hardly anyone in the various samples attributed the hitting of the "jackpot" to luck.

On the other hand, farmers attributed their losses to two major causes: (1) poor yield or crop destruction due to lack of water, typhoons or bad weather, and outbreak of pest and diseases and (2) low market prices.

Results of the Decision Model

The model on cropping decision making found empirical support in the various cases except for the mungbean case which was not really a free choice situation for the farmers given that NIA had programmed the area for mungbean production. This suggests that the model was more applicable to free choice situations where farmers have a number of alternative crops to choose from.

Results from the model on cropping decision making yielded important points to consider on crop diversification. These considerations can be used by change agents as a guide to determine whether or not fanners are ready for crop diversification. Table 1 shows a sample of the model's results which are presented in brief as follows:

1. Farmers are willing to diversify during the dry season if their family's rice consumption requirements for the year are met by their wet season rice crop and other sources of income as this gives the farmer greater leeway to face greater risks during the dry season. This points to paying more attention to the wet season rice crop in efforts at encouraging crop diversification during the dry season.
2. The crop must be perceived as technically feasible by the farmer. In particular, the farmer must perceive it as suitable to the soil and topography of his farm and he must perceive the timing of the cropping season as *right,* i.e., it suits his wet season schedule and at the same time has a good chance of hitting the high market price at harvest time. The irrigation water available must also be perceived as being sufficient to support the crop. Nonetheless, the fact that many farmers complained of inadequate water suggests that many farmers planted the diversified crop even if he was not absolutely certain that there would be enough water.
3. The crop must be perceived as economically feasible by the farmer. Sources of credit, if needed, must be readily available. There must also be an assured market for the produce. In this regard, the contract growing scheme is considered a good means of assuring the farmer of the crop's economic feasibility. However, as in tomato and cotton, certain points must be considered for the scheme to succeed. First, a fair market price must be paid for the produce (as in the case of the cotton farmers) because if the price is too low (as in the case of the contract grown tomatoes), the only way for the farmers to realize a profit is to have very high yields which is not very realistic given the conditions under which most farmers operate. Many of the tomato fanners were quite unhappy when their produce was sold at ₱0.80/kg to PFVII when the market price for native tomatoes ranged from 910 to ₱14/kg. *Second,* the yield estimates given to the fanners must be realistic. The 40 t/ha

Table 1. Crop decision making: mungbean versus alternative crop tomato.

	Munghean		Tomato	
Stage 1. Assuring rice consumption requirements				
• Rice consumption requirement met?				
Yes = 21 No = 19				
• Non-rice crop allows meeting rice consumption requirement?				
Yes = 8 No = 11				
Stage 2. Testing for feasibility	N	%	N	%
Technical constraints:				
Soil, topography	40	100.0	24	60.0
Water	40	100.0	40	100.0
Timing	40	100.0	38	95.0
Knowledge	40	100.0	39	97.5
Economic feasibility:				
Demand	40	100.0	40	100.0
Time, labor	40	100.0	39	91.5
Capital, credit	40	100.0	40	100.0
Stage 3. Benefit-cost analysis				
• Perceived profitability of crop meets farmer's minimum profitability requirements?				
Yes	21	52.5	9	22.5
NO	19	47.5	31	77.5
Summary				
1. Total number of farmers who passed all conditions of the decision tree:	16	40.0	6	15.0
a. number who planted the crop	16	40.0	6	15.0
h. number who did not plant the crop	0	0.0	5	12.5
2. Total number of farmers who did not pass one or more conditions of the decision tree:	21	52.5	34	85.0
a. number who planted the crop	21	52.5	2	5.0
b. number who did not plant the crop	16	0.0	32	80.0
3. Total number of farmers whose behavior is				
a. consistent with the predictions of the model		40.0	33	82.5
b. inconsistent with the predictions of the model	21	52.5	7	17.5
c. cannot be determined	3	7.5		

potential yield of the California variety tomato given to the farmers by PFVII created false expectations. Had the farmers been given more realistic estimates, they would probably have been more prudent in their input expenditures. Third, the farmers must be given sound advice by the technicians regarding the use of inputs (especially pesticides) and must be aided to be made more aware of their input expenditures during the course of the cropping season.

4. The availability of hired labor was not a crucial economic variable because family labor was used. The heavy use of family rather than hired labor was critical to the overall economic viability of diversified cropping in general, (except in the case of mungbean), as diversified crops are more labor-intensive than rice. This implies that crop diversification is more viable for small farm areas which the family can work on because there is a need to get more hired labor with larger areas which will adversely affect the net cash returns. There is also a positive aspect to the high utilization of unpaid family labor in the growing of diversified crops. Planting diversified crops utilizes excess family labor who would otherwise be unemployed or underemployed during the dry season. Increasing

the practice of exchange labor for labor intensive activities like land preparation and transplanting can greatly reduce the laborcashcost (asinthecaseofthe tobacco farmers). In this regard, change agents advocating for crop diversification should direct some attention to helping farmers in adjacent areas organize for exchange labor during these activities. The water-users' association can he agood vehicle fordoing this.

5. Benefit-cost analyses indicated that farmers tend to have high minimum profitability requirements for the diversified crop compared with rice, *so* as to offset high risks involved. This implies that for a farmer to agree to plant a diversified crop during the dry season, he must be sufficiently convinced that it will yield high returns and not just marginally higher returns than rice. Results of the interview showed that farmers were willing to plant crops that require more time, input and labor than rice provided a high profitability is perceived. Farmers were also willing to plant diversified crops that was categorized under the minimum profitability which they would like to realize, if they did not have much choice (e.g., not enough water for planting rice and no other alternativecrops feasible under the circumstances, as in the case of the mungbean farmers) or if the other choices were no better than the crop under consideration, provided profit will he realized from the venture.

Lack of water for the diversified crop was a problem for some farmers during the dry season. Farmers used irrigation water during land preparation, transplanting and fertilizer application and they irrigated theirdiversified crop at certainstages of crop growth (e.g., flowering stage, fruiting stage) and/or at regular intervals (e.g., every 14 days). Other indicators for determining that a crop needs water were: wilting and/or curling of leaves and the dryness/cracking of the soil.

Generally, the water-users' associations had little to do with crop diversification beyond irrigation related matters such as repair and maintenance of canals, irrigation schedule, arbitrating in water-related disputes among farmers, and bringing to the attention of the watermasters or **NIA** the irrigation-related problems of the farmers. In this regard, water-users' associations are potentially good organizational resources to tap in crop diversification programs. In particular, the association could be tapped as a support system for farmers engaging in crop diversification as results show that the influence of other farmers is important in the decision to plant diversified crops. The associations could also be tapped in the marketing of the diversified crop and they could also be used as an informal (or even formal) credit mechanism for the farmers.

The need for a good credit mechanism in the promotion of crop diversification must be emphasized as shown in the higher cash costs for the majority of the diversified crops compared to rice. Since most farmers did not have adequate capital to meet the cash needs, a good credit mechanism will encourage farmers to plant diversified crops.

The costs and returns data for all of the cases except the Ilocos region reveal an alarming level in the use of pesticides by farmers. The unnecessary use of pesticides is a function of farmers' averting risk. Farmers were willing to pay the high costs of pesticides as a mitigating measure to crop loss. There is a need to educate farmers on proper pest management practices.

Although farmers expectations of the crop tended not to be too far off the crop's actual performance, nevertheless, farmers usually overestimated gross returns, underestimated cash expenditures, and overestimated net returns above cash costs. From the psychological point of view, this is an ***optimism mechanism*** that helps farmers cope with adverse circumstances that they have to operate in. If farmers are pessimistic, they might as well not try.

One important finding, with respect to the marketing of the produce, was the relatively large volume of sales during harvest time and a few weeks after. The volume of the sales at a time when market prices were low underscored the need for cash during harvest time such that farmers sold large quantities of their produce at less than the potential price which they could obtain at a later date. This was one reason why the diversified crop was not as profitable for the farmer as expected. Projects and programs aimed at promoting crop diversification should then direct some of their efforts at establishing viable market mechanisms (e.g., marketing cooperatives) and storage facilities that will help farmers obtain better returns for their produce. The water-users' associations could also be used as an organizational vehicle for this.

Summary

Results of the case studies indicate that the following conditions were conducive to the adoption of crop diversification during the dry season:

- insufficient irrigation water for rice during the dry season
- low levels of income from other sources
- successful and profitable experience of other farmers
- farmers in nearby fields planted the crop
- lack of a better alternative under the prevailing circumstances
- the wet season rice crop and other sources of income were able to provide for the family's rice consumption requirement for the year
- the crop was perceived as technically feasible (i.e., it was suitable to the soil and topography of the farm, cropping season was on time and sufficient irrigation water was available)
- availability of seeds
- the crop was perceived as economically feasible (i.e., readily available market, credit and labor were available)
- the farmer believed that the crop will yield higher returns and not just marginally higher than rice
- an assured selling price (as in a contract growing scheme) or the market price of the crop does not fluctuate too much (i.e., it is not a price *risky* crop)
- presence of support structures technical assistance, credit mechanism and a viable marketing system.

Results also indicate that the following conditions were conducive to the success and persistence of crop diversification during the dry season:

- the persistence of crop diversification was strongly related to a trend of positive net returns punctuated by occasional *jackpots*
- high yields due to proper cultural management practices
- high prices
- a fair market price is paid for the produce as in contract growing schemes
- the potential yield estimates given to the fanners were realistic
- less use of pesticides; better pest management techniques
- greater awareness among farmers of their input expenditures during the cropping season
- available family labor best suited for small farms
- increased practice of exchange labor for labor-intensive activities like land preparation and transplanting
- planting the same diversified crop within the same locality.
- sufficient irrigation water
- good credit mechanism due to higher cash costs of diversified crops as compared with rice
- a viable marketing mechanism that will help farmers obtain better returns for their produce

The Economics of Diversifying into Irrigated Non-rice Crops in the Philippines

Leonardo A. Gonzales [1]

Abstract

This paper analyzed the financial and economic viabilities of irrigating non-rice crops in two regions in the Philippines during the dry season, using the domestic resource cost (DRC) approach. Data from IIMI-IFPRI survey in **1985** and the IIMI follow-up survey in 1987 were used to compare the financial and economic profitabilities of **six** crops: rice, corn, mungbean, peanut, onions and garlic.

Results showed that only white open pollinated corn had negative net financial profitability among the six crops analyzed. The domestic production **of** irrigated onions in Central Luzon. peanut and garlic in the Ilocos Region, exhibited high financial profitabilities.

The DKC analysis also indicated that garlic, onion and peanut production systems are economically efficient users of irrigation water. Except for mungbean and white open pollinated corn, other irrigated crop production systems examined were economically efficient **as** import substitutes (rice and peanut) and as exports (garlic and onions).

Results from the economic analysis indicate a high potential in using irrigation water for non-rice crops. Research on the technical, economic and social viability of this new management practice should be encouraged.

Introduction

In Philippine agriculture. rice has been the major user of irrigation water. This **is** understandable considering the importance of rice as a major staple and the multiplier effects that irrigation water has on rice production. Lately, however, questions have been raised whether there **is** economic efficiency in the use of irrigation water to non-rice crops. This paper assesses the economics of diversifying into non-rice crops using the domestic resource cost (DRC) approach with emphasis on the role of irrigation water.

Irrigated rice was compared with five non-rice crops (corn, mungbean. peanut, garlicand onions) during the dry season in two selected regions (Ilocos and Central Luzon) in the Philippines using the 1985IIMI-IFPRI farm level production survey and the **1987** IIMI follow-up survey.

Economics of Crop Diversification: A Domestic Resource Cost Approach

This paper approaches the problem of economic efficiency using the domestic resource cost (DRC) concept. DRC **is** defined as the ratio of domestic cost and border price of output minus foreign cost or expressed as:

$$\text{DRC} = \frac{\textbf{domestic costs in shadow prices per unit of output}}{\textbf{(border price of output)} - \textbf{(foreign cost per unit in border price)}} \qquad (1)$$

The numerator **is** expressed in local currency while the denominator **is** expressed in foreign currency, resultingin the "own exchange rate" for theactivity. Mcdallaand Power (1979) argued that the rationale for using DRC as a measure of relative efficiency **is** the importance **of** the foreign

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exchange constraint on Philippine economic development.

The DRC as a measure of comparative advantage can be compared with the shadow exchange rate (SER) of foreign exchange like in investment criterion of benefit cost analysis. Bruno **(1972)** postulated that depending on the ratio of DRC/SER, sometimes referred to as "resource cost ratio" (RCR), an economic activity can be determined whether it has relative comparative advantage for a country. Thus if,

(a) $\frac{DRC}{SER} < 1$, → comparative advantage

(b) $\frac{DRC}{SER} = 1$, → neutral advantage/disadvantage

(c) $\frac{DRC}{SER} > 1$, → comparative disadvantage

There are several procedures in calculating DRC[2]. First, **is** to have adequate knowledge on the production costs of the different production systems and be able to value these costs at their opportunity costs and at the appropriate marketing chains. Second, is a consistent method of allocating production cost into their domestic and foreign economic cost components. The calculations of the economic costs of inputs should be net of taxes or subsidies. **Also,** the value **of** output should be computed into border price equivalents, i.e. freight on board (FOB) for exports and cost, insurance, freight (CIF) for imports. Table 1 summarizes the border prices of the commodities included in the analysis.

Rice, corn, mungbean and peanut were analyzed as import substitutes while garlic and onions were evaluated as exports. At one point in the analysis, the long term border prices of rice and corn were incorporated to present a long term view on the economic prices of these two major grains.

Table 1. Border and domestic prices used for **DRC** calculations, 1987.

Commodity	Trade Regime	Border Price ($/mt)	Domestic Price Farmgate (₱/kg)	Domestic Price Wholesale (₱/kg)
Rice	Import Substitution			
Current		267 28 (CIF)	2.77	4 72
Long term[a]		336.28 (CIF)	2.77	5.12
Corn	Import Substitution			
Current		**138.62** (CIF)	3.02	3.30
Long term[a]		174.28 (CIF)	3.02	**3.30**
Mungbean	Import Substitution	302.45 (CIF)	13.70	14.60
Peanut	Import substitution	307.29 (CIF)	11.10	19.80
Garlic	Export Promotion	715.00 (FOB)	10.30	17.97
Onion	Export Promotion	291.00 (FOR)	4.07	10.14

[a]Based on 10-year moving average, 1970-87.

[2]For specific assumptions and sample calculations using this method as applied to the Philippines, refer to Rosegrant et al., (1987).

Another crucial aspect in the DRC calculations is the choice of shadow prices used in costing the different inputs. The shadow prices of land, labor, cost of capital (interest) and the cost of foreign exchange, should be priced carefully to avoid distortions in the calculations.

Empirical Results

Given the different farm budgets by crop enterprises, two profitability indicators can be derived: net financial and economic profits. The difference lies in the use of prices as a tool for valuation. In determining net financial profit (whether on-farm or at wholesale), actual domestic market prices encountered by farmers or traders are used. In contrast, net economic profit, is calculated using border prices or economic prices, i.e , net of tax or subsidy, to value both inputs and outputs.

Financial und economic *profitability* In profitability analysis, yields, production costs and prices are crucial in the calculations. Table 2 summarizes the yields and net financial profitability on-farm and at wholesale of the different irrigated crop enterprises. On the average, irrigated rice production systems in Central Luzon had higher yields (4.39 t/ha) than in the llocos Region (3.61 t/ha), and consequently had higher on-farm net financial profit.

Across the two regions, onion had the highest net financial profit on-farm o f f11,838/ha; peanut (₱10,680/ha) and garlic (₱9,832/ha) ranked next to onion in that order (Table 2). Of the six production systems analyzed, only white open pollinated corn exhibited negative financial profit. Data in Table 2 also indicate that traders, middlemen and wholesalers had substantial profits in onion, garlic and peanut. This is due to seasonality and monopolistic element (limited entry) in the domestic trading of these commodities.

At the wholesale level, it is important to note the divergence between the financial and the economic profitabilities among the crops. The economic profits (Table 3) represent the undistorted valuation of the commodity at the wholesale level. Therefore, if the financial profit is higher than the economic profit, it shows that the difference was partly due to government intervention (protection) of imperfections in the marketing system. Such was the caseformungbean. The net economic profit of mungbean production, given the economic valuation of the mungbean production system was negative, yet its net financial profitability was positive. The data further showed that where a positive government output price protection for a commodity exists, a negative divergence between net financial and economic profitability usually follows, This was true for all crops examined with the exception of rice (Table 3).

Table 2. Yields and financial profitability, on-farm and wholesale of different irrigated crop production systems. llocos and Central Luzon, **1987.**

		Net Profit'	
Crops	Yield (t/ha)	On-farm (₱/ha)	Wholesale (₱/ha)
llocos Region			
Rice	**3.61'**	**2,077**	**1,214**
Munghean	**0.88**	**5,607**	**6,147**
Peanut	**1.80**	**10,680**	**25.127**
Garlic	**2.42**	**9,832**	**25,990**
Central Luzon			
Rice	**4.39'**	**2,523**	**2,743**
Onion	**10.66**	**11,838**	**64,350**
Corn	**2.36**	**- 536**	**- 622**

"Residual after subtracting total costs from Gross Revenue
[b]ln paddy equivalent, the milling rate is **0.65.**

Table 3. Comparison of net financial and economic profitability at wholesale, different irrigated crop production systems, llocos and Central Luzon, **1987.**

	Net Profitability at Wholesale (₱/ha)	
Crao	Financial	Economic
llocos Region		
Rice	**1,214**	**1,953**
Munghean	**6,147**	**–3,279**
Peanut	**25,727**	**1,210**
Garlic	**25,990**	**21,286**
Central Luzon		
Rice	**2,743**	**3,319**
Onion	**64,350**	**26,407**
Corn	**–622**	**–3.882**

Comparative *advantage* analysis. Table **4** shows the results of the DRC analysis. Economic efficiencies in the domestic production of rice, corn, mungbean and peanut **as** import substitutes were evaluated. Analysis was also conducted in the domestic production of garlic and onion **as** exports. Results showed that the domestic production of irrigated mungbean and white open-pollinated corn had **no** comparative advantages **as** import substitutes. Calculated DRCs **of** irrigated mungbean and white open-pollinated corn were about **35** which was higher than the **peso's** shadow exchange rate (SER) of **₱25:$1** in 1987. Consequently, the resource cost ratios (RCRs) of these crops were greater than one (1.40), implying a comparative disadvantage (Table **4).**

Table 4. Calculated economic efficiency indicators for different irrigated crop production systems, by trade regimes, llocos and Central Luzon, **1987.**

Crop	Trade Regime	Efficiency Indicators DRC[a]	RCR[b]
Ilocos Region			
Rice[c]	Import Substitution	**17.13**	**0.69**
Rice[d]	Import Substitution	**12.53**	**0.50**
Mungbean	Import Substitution	**34.78**	**1.40**
Peanut	Import Substitution	**18.40**	**0.74**
Garlic	Export Promotion	**7.67**	**0.31**
Central Luzon			
Rice[c]	Import Substitution	**15.44**	**0.62**
Rice[d]	Import Substitution	11.14	**0.45**
Onion	Export Promotion	**12.32**	**0.50**
Corn	Import substitution	**34.71**	**1.40**

[a] DRC = domestic resource cost.
[b] RCR = resource cost ratio i.e. the ratio of DRC with the shadow exchange rate (SER) of the total currency.
[c] at **1987** border price of **35%** broken milled rice,
[d] at long term border price of 35% broken milled rice, using a 10-year moving average.

Among the irrigated non-rice crops examined, garlic for export was the most economically efficient with an RCR of **0.3**1. Although irrigated onion and peanut were also efficient import substitutes with RCRs of 0.50 and 0.74, respectively, irrigated rice in Central Luzon, evaluated at its long-term border price was still more economically efficient than these two crops with an RCR **of 0.45** (Table **4).**

Results of the analysis indicate that despite the high economic cost of irrigation water (Table **5)** due to the high subsidies (Table 6) for the specific irrigation systems in the two regions, garlic, onion and peanut production demonstrated that they are economically viable alternative production systems to rice in the use of irrigation water. For mungbean and white open pollinated corn, the problem lies in their relatively low yields (technology). In general, farmers have not totally adjusted their management practices **lo** effectively grow mungbean, corn, and other irrigated non-rice crops.

Table 5. On-farm financial and economic costs of irrigation water by crop production systems, dry season, llocos and Central Luron, Philippines, **1987.**

Crop	Cost of Irrigation Water (₱/ha) Financial	Economic[a]
Ilocos		
Rice	**415**	**3,347**
Mungbean	**249**	**2,008**
Peanut	**249**	**2,008**
Garlic	**249**	**2,008**
Central Luzon		
Rice	**473**	**6.662**
Corn	**284**	**4,000**
Onion	**284**	**4,000**

[a] Calculated at **87.6%** and **92.9%** subsidy rates for llocos (LVRIS) and Central Luzon (UTRIS) irrigation systems, respectively.

Table 6. Estimate of subsidy in irrigation for Laoag-Vintar River Irrigation System (LVRIS) and Upper Talavera River Irrigation System (UTRIS), 1987.

Items	LVRIS	UTRIS[4]
***Total capital investment cost* (₱/ha)[1]**		
Financial cost (₱/ha of service area)	40,787	39,591
Economic cost (₱/ha of service area)[2]	35.885	34.833
Annualized economic cost of investment (₱/ha)	5,388	5,230
Annual cost of operation and maintenance (₱/ha)	583	2,276
Total annualized economic cost (₱/ha)	5,971	7,506
NIA-charges irrigation fee		
Wet season: 100 kg/ha	367	391
Dry season: 150 kg/ha	374	142
(economic price of palay each ₱3.67/kg)		
Cropping intensity	1.68	1.26
Effective irrigation fee/ha/yr	741	533
Percent subsidy $\left(1 - \frac{\text{annualired cost}}{\text{effective fee}} \times 100\right)$	87.80	92.90

[1]Includes construction and rehabilitation costs.
[2]Based on average implicit tariff (IT) for imported raw materials of 13.65%
[3]Based on 15% discount rate. 50 years life span of the structure
[4]NIA charged irrigation fee 25 kg/ha/season higher than LVRIS. The economic price of palay was P3.13/kg in 1987

Source of basic data: NIA

Sustainability of comparative advantage. Comparative advantage analysis is a dynamic concept. Therefore, results based on 1987 data should be considered as static indicators of the dynamic process towards economic efficiency. There are, however, several factors that determine the sustainability of comparative advantage. Among these are the resource endowments (agro-climatic) factors of the region where the crop production systems take place, farm level management that determines the technology and cost structure of the production system, and the economic environment (economic policy, domestic and international trade). The optimum interplay of these factors would determine the sustainability of competitiveness in the long-run.

Analysis of irrigated non-rice crops showed that at the given production cost and border prices for mungbean and white corn in 1987, yields should at least reach **1.20** t/ha and **3.23** t/ha, respectively, in order to maintain competitiveness as import substitutes (Table 7).

Table 7. Actual and breakeven yields for different irrigated crop production systems at given border prices. Ilocos and Central Luzon. Philippines, 1987.

Crops	Border ($/t)	Yield (t/ha)	
		Actual	Breakeven
Ilocos Region			
Rice	267.28	3.61[a]	1.63[a]
Mungbean	302.45	0.88	1.20
Peanut	307.29	1.80	1.34
Garlic	715.00	2.42	0.38
Central Luzon			
Rice	259.77	4.39[a]	1.84[a]
Corn	138.62	2.36	3 23
Onion	291 00	10.66	4.96

[a]Unhulled rice

For other commodities, such as garlic, onion, rice and peanut, breakeven yields to sustain comparative advantage were relatively lower than yields in 1987. This implies that if border prices and the structure of costs of production do not drastically change, the Philippines can sustain economic efficiency in domestically producing these irrigated crops.

Summary and Conclusions

The analysis compared the financial and economic viabilities of irrigated rice production with five irrigated non-rice crops. Results indicate that irrigated garlic, onion and peanut production systems were viable economic alternatives to rice in the use of irrigation water. Mungbean and white open pollinated corn, however, were not economically efficient production systems considering their low yields per hectare and the relatively high economic costs of irrigation water. Sensitivity analyses further showed that the Philippines can sustain long-term economic competitiveness in the production of irrigated garlic, onions, rice and peanut provided the cost of production and border prices of these commodities do not drastically change.

Finally, one should bear in mind that comparative advantage is a dynamic concept. Although results from the analysis are static in nature, the power of this analytical tool is its ability to examine alternative directions for policy reforms which insure that scarce resources can be allocated more efficiently.

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Irrigation Investment and Crop Diversification: A System-Level Analysis

Ricardo A. Guino and Leonardo A. Gonzales [1]

Abstract

The economics of irrigation investment of four national irrigation systems (NIS) were analyzed under rice-mungbean, rice-peanut, rice-corn, rice-garlic and rice-onion cropping patterns. The four **NIS** were: Laoag-Vintar (LVRIS), Bonga Pump No. 2, Tarlac-San Miguel-O'Donnel (TASMORIS), and Upper Talavera River Irrigation System (UTRIS).

Results from the benefit-cost analyses indicate low levels of benefits and rate of return across cropping patterns for **all** irrigation systems. This low rate of return **as** reflected by the low BCRs could be attributed to high capital investment cost and high operation and maintenance cost.

Sensitivity analysis was applied to evaluate whether additional investment for rehabilitation designed for crop diversification can he offset by the benefits from irrigating non-rice crops. Results showed that low IRRs and BCRs cannot justify investment in rehabilitation.

Introduction

The Philippine government, through the National Irrigation Administration **(NIA),** has pursued extensive construction of new irrigation systems and intensive development of existing systems through the rehabilitation and upgrading of infrastructure and improvement of systems management.

The importance of irrigation as a mechanism for the country's agricultural growth and development is widely accepted. Not only does it harness the potential of high yielding rice varieties, it **also** facilitates the diffusion and adoption of several recommended practices and complementary inputs. There is a need to produce more rice to meet increasing demand due to population pressure but crop diversification offers more food sources and opportunities **for** the country to save foreign exchange (Gonzales, 1984).

Investments in irrigation in the country were mainly designed for rice. It was hypothesized that due to the increasing costs in developing new irrigation system, there will be shifts in the use of irrigation water for non-rice crops. However, there are still unresolved issues regarding the economics of irrigating non-rice crops. One issue **is** whether irrigation investment is financially and economically viable if diverted to non-rice crops. This paper analyzes the financial and economic viabilities of irrigation investment using the benefit-cost approach to determine whether capital investment on irrigation can give higher return on investment among irrigating non-rice crops.

Review of irrigation investment **From** 1965 to 1982, annual growth rate in irrigation investment averaged 43% hut remained almost constant from 1983 to 1987. This trend was partly attributed to the shift in government investment priorities and partly because of budget constraints (Table I). As a consequence, irrigation development accounted fur 47% of the 3.1 million hectares potential irrigable area. While these irrigation systems were designed to irrigate rice, they **also** accommodate to a minor extent, non-rice crop. In 1985, there were about 20,450 hectares planted to irrigated non-rice crops (Table 2). However, NIA estimated that there were about 209,777 hectares of potential diversified cropland under irrigation.

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Table 1. Investments in irrigation in the Philippines, 1965-87.

Year	Total Investment (000,000₱) At current price	At constant 1987 prices
1965	5.60	8.69
1966	20.12	280.28
1967	19.58	262.44
1968	23.60	297.17
1969	43.99	535.18
1970	114.80	1202.11
1971	137.92	1303.60
1972	240.04	2112.98
1973	390.11	2906.93
1974	744.10	3459.32
1975	922.18	4263.43
1976	760.55	3257.17
1977	1160.46	4608.66
1978	1627.15	5934.17
1979	2038.89	6212.34
1980	2107.70	5522.88
1981	2248.01	5182.14
1982	2366.89	5075.89
1983	1741.76	3395.25
1984	1570.80	2052.26
1985	1700.00	1874.10
1986	1729.80	1816.25
1987	1745.90	1745.90

Since 1983, government expenditures on irrigation drastically decreased due largely to the country's financial problems. NIA has to set back its irrigation investment plan of 1983. Moreover, the economic costs of constructing new irrigation systems has significantly increased, thereby making it more appropriate to diversify the use of irrigation water for other crops. As an alternative strategy, rehabilitation of old irrigation system is necessary to facilitate the production of non-rice crops during the dry season.

In a study, Rosegrant, et al., (1987) disclosed that the NIA investment plan was inadequate to provide for the necessary productivity increases to meet growth in domestic demand for rice. Such inadequacy was due to planned levels of irrigation investments which were not based on long-term food production requirements but as a result of the government's financial crisis. Based on the NIA investment plan, rehabilitation constituted only 30% of the total planned investment while the rest was allocated for the construction of new irrigation systems. Although these planned rehabilitation schemes were intended to irrigate rice, policy decisions should be weighed to consider rehabilitating irrigation systems for crop diversification. This is very crucial in the light of the foreign exchange constraint being faced by the Philippines

Table 2. Crop diversified irrigated area (ha) by region, Philippines, 1985.

	Potential Irrigated Area	NIA Irrigated	Estimated Diversified Cropland	Actual Irrigated Diversified Crop Area
1	309,810	179,887	12,299	15,140
2	539,710	249,404	36,538	20
3	482,220	284,490	33,852	40
4	263,590	139,032	30,735	60
5	239,650	149,110		0
6	197,250	106,002	13,137	0
7	50,740	19,771		0
8	84,380	67,880		0
9	76,500	34,461		0
10	230,150	62,592	3,015	0
11	290,250	89,890	33,118	790
12	362,080	98,134	18,140	4,400
TOTAL	3,126,330	1,480,653	209,777	20,450

Source: NIA

today. If this rehabilitation plans for crop diversification becomes economically feasible, then millions offoreign exchangecan be saved (Gonzales, 1984).

Methodology

Benefit-cost analysis was applied to assess the financial and economic viabilities of irrigation investments at the system-level. System-level analysis describes the performance of each irrigation system in terms of economic viability. to determine whether benefits derived from irrigating non-rice crops can offset investment cost. Using two basic criteria: benefit-cost ratio (BCR) and internal rate of return (IRR), the system's viability with respect to rice-non-rice cropping patterns under irrigated conditions was estimated.

Sensitivity analysis was applied to each system to determine whether incremental costs of rehabilitation can still hc offset by the benefits obtained from non-rice crops during the dry season.

Irrigating non-rice crops is a relatively new concern in the Philippines. There are no existing irrigation systems designed to irrigate non-rice crops. In the absence of a detailed cost estimates for rehabilitation, the 1986 **NIA** draft plan of rehabilitation cost was applied (Table **3).** The rehabilitation cost/ha was ₱10,816 at 1987 prices. This rehabilitation cost per hectare was applied to the service area of each of the four irrigation systems (Table4) in order to derive the total rehabilitation cost for the wholesystem. Thecomputed IRRs and BCRs were used as indicators whether the incremental benefits derived after rehabilitation were enough to cover the incremental costs incurred. Data obtained for the analysis were capital investment costs. operation and maintenance costs, and computed values **of** net benefit.

For the irrigation component, real values of capital investment and operation and maintenance were adjusted to 1987 prices. Since the IFPRI-**ADB** nationwide irrigation survey (Phase I) was unable to gather disaggregated investment costs for each individual irrigation system, a generalized inventory of construction items was developed. The generalized inventory was used to facilitate the computation of each system's economic cost components for construction materials. Construction costs were classified according to tradeable and non-tradeable components. Tradeable construction items were cement. reinforcing steel bars, nails and wires, fuel and oil, spare parts and heavy equip-

Table 3. Planned investment costs for construction and rehabilitation, **1986** NIA draft investment plan, **1987-1996** (at **1987** prices).

	Planned Investment Costs		Cost/ha of Service Area (₱/ha)
	Amount ('000,000₱)	Percent	
New Area	*13,909*	70	
National reservoir	**5,404**	**39**	
National diversion	**6,535**	**47**	**48,048**
Communal	**1,970**	**14**	**25,272**
Rehabilitation	*5.805*	*30*	**10,816**
National reservoir			
National diversion	**4,461**	*11*	
Communal	**1,345**	**23**	
Total	*19,714*	*100*	
National reservoir	**5,404**	**27**	
National diversion	**10,996**	**56**	
Communal	**3,315**	**17**	

“Rehabilitation cost includes new area cost. Disaggregation not available.

Source: Rosegrant, et al., **1987.**

Table 4. Basic information of the four national irrigation systems.

System	Service Area (ha)	Benefited Area Wet (ha)	Benefited Area Dry (ha)	Location/ Region
Laoag Vinrar River Irrigation System (LVRIS)	2,311	**2,204**	**1,423**	Laoag, llocos Norte/ Ilocos
Bonga Pump (BP#2)	614	**450**	**275**	Laoag, llocos Norte/ Ilocos
Tarlac-San Miguel-O'Donnel River Irrigation System (TASMORIS)	17,075	9,159	3,156	Tarlac/ Central Luron
Upper Talavera River Irrigation System (UTRIS)	3,629	3,598	921	San **Jose,** Nueva Ecija/ Central Luzon

ment. Economic prices (i.e., the market price which is net of subsidies and taxes) of tradable items were estimated based on **CIF** prices, **if** they were imported, and on FOB prices, if exported. Oh the other hand, non-tradeable items or domestic components included sand, gravel, labor and management. **All** costs (i.e. real values of capital investment and operation and maintenance cost) were adjusted to **1987** prices.

Computed net benefits for rice-non-rice cropping pattern were derived from the basic farm budgets using different production technologies. Given the different cropping patterns, the comparative performance of each system was also assessed. Using two indicators, net financial profit (NFP) and net economic profit (NEP), financial and economic profitabilities were derived for each non-rice crop. Five irrigated non-rice crops were evaluated: corn, mungbean, peanut, garlic and onion. Financial analysis of non-rice crop was based on market prices at wholesale while economic analysis was based on the economic prices for inputs and border price or world market price for outputs. In general, the methods and assumptions of this study were patterned after the procedure of Gonzales **(1984)** study on crop diversification.

Benefits and Rates of Return from Crop Diversification

Results generally indicate low benefits and returns to irrigation investment. Sensitivity analysis on the additional investment for rehabilitation designed to irrigate non-rice crops showed low IRRs and BCRs.

Laoag- Vintar River Irrigation System (LVRIS). **LVRIS** was built in **1930.** Its designed service area was **2,377** hectares. Because of siltation resulting in reduced canal capacities and inefficient water distribution, the system was rehabilitated in **1977.** Rehabilitation was funded by the World Bank under the National Irrigation System Improvement Project (NISIP). The rehahilitation involved improvement **of** the existing facilities. **An** additional 149 hectares was added to its service area. However. due to wear and tear, the current benefited area is only **2,204** hectares with a cropping intensity equal to 1.64. The benefited area includes 586 hectares planted to non-rice crop during the dry season. Non-rice crops traditionally planted by llocano farmers were garlic, peanut, onions. mungbean, tomato, watermelon and corn.

Irrigation fee for non-rice crops is **60%** of the equivalent fee for rice. Irrigation fee for rice is 100 kg of paddy/ha during the wet season and 150 kg of paddy/ha during the dry season. Financial cost of irrigating rice is 100 kg multiplied by the prevailing market farm gate price. The economic cost of irrigation is computed by valuing the irrigation service fee at the economic price of rice and adjusting lor the irrigation subsidy.

Results show that LVRIS was financially viable for rice-peanut cropping pattern with 15.56% FIRR. However, the system was not Economically feasible for rice-mungbean and rice-peanut cropping patterns because of negative FIRR (Table *5).*

Table 5. Internal rate of return (IRR) and benefit-cost-ratio (BCR) for rice-non-rice cropping pattern by system, Luzon, 1987.

System / Cropping Pattern	Financial		Economic	
	IRR(%)	BCR*	IRR(%)	BCR*
LVRIS				
Rice-Mungbean	8.75	0.56	Negative	
Rice-Peanut	15.56	1.05	Negative	
BP # 2				
Rice-Garlic	8.38	0.63	3.73	0.47
TASMORIS				
Rice-Corn	Negative		Negative	
UTRIS				
Rice-Corn	14.62	0.97	3.46	0.39

* at 15% discount rate

Rice-mungbean cropping pattern gave lower rate of returns on investment, with an IRR of *8.75%* and a BCR of 0.56 at 15% discount rate. On the other hand, rice-peanut cropping pattern showed a marginal rate of return with BCR of 1.05.

Bonga Pump No. 2 Irrigation System (BP # 2). BP#2 is one of the three Bonga pumps being operated by NIA. It is a surface-type irrigation system with a service area of 674 hectares. BP#2 serves the towns of Laoag and San Nicolas in Ilocos Norte. BP#2 was built in 1959 simultaneously with two other Bonga pumps. The pumps are electrically powered. In 1979, BP#2 was rehabilitated due to engine breakdown.

The total benefited area was 725 hectares - 450 hectares planted to rice during the wet season, and 275 hectares during the dry season. Of the area planted during the dry season, 125 hectares were planted to non-rice crops, mostly garlic. Unlike other systems, BP#2 charges 300 kg/ha paddy equivalent for non-rice crops.

Farm budgets indicate that garlic production system was both financially and economically profitable in BP#2. Garlic was the most popular and widely planted non-rice crop in Ilocos Norte.

In spite of the low wholesale price for garlic (P17.97/kg), the crop was still highly profitable because of its high yield (2.5 t/ha). However, rice-garlic cropping pattern exhibited low FIRR (8.38%). This low rate of return was attributed to high operation and maintenance cost (Table 6).

Table 6. Capital investment of four national irrigation systems, Luzon, at 1987 prices.

System	Benefited Area		Capital Investment (₱/benefited area)		Operation and Maintenance Cost (₱/benefited area)
	Wet (ha)	Dry (ha)	Financial	Economic	
LVRIS	2,204	1,423	28,259	24,863	360
BP#2	450	275	29,591	26,203	2,252
TASMORIS	9,159	3,156	10,984	9,664	295
UTRIS	3,598	927	31,752	27,936	1,441

Tarlac-San Miguel-O'Donnel River Irrigation System (TASMORIS) TASMORIS serves the towns of Gerona, Pura, Victoria, La Paz, Capas and Concepcion, in the province of Tarlac. The designed service area is 17,075 hectares with a very low cropping intensity. Benefited area was 9,159 hectares or 53% of the service area during the wet season and only 3,156 hectares or 18% of the service area during the dry season.

TASMORIS is composed of three independent irrigation systems which were built separately but was merged into one for operation and maintenance. The three systems are the Tarlac River Irrigation System (RIS) which was built in 1959; the San Miguel RIS, built in 1913 and O'Donnel RIS, constructed in 1927.

In TASMORIS, where irrigated white open pollinated corn was widely planted, analysis showed that the irrigated rice-corn pattern could not justify the financial and economic viabilities of the system. The negative FIRR and EIRR under the rice-corn pattern in TASMORIS attest to this (Table 5).

Upper Talavera River Irrigation System (UTRIS). UTRIS is located upstream of the Talavera River serving the city of San Jose, Nueva Ecija. UTRIS is composed of the Talavera RIS constructed in 1923 and San Agustin Extension built in 1956 with a combined designed service area of 3,629 hectares. With the construction of Pantabangan dam also known as the Upper Pampanga River Project (UPRP) in 1975, UTRIS was integrated with the Upper Pampanga River Integrated Irrigation System (UPRIIS) but without generating additional service area.

UTRIS has a benefited area of 3,598 hectares during the wet season and 927 hectares during the dry season; 465 hectares of the benefited area is planted to non-rice crops. UTRIS was designed to irrigate rice during both wet and dry seasons. However, most farmers shifted to non-rice crops during the dry season. The most popular and profitable crop in Central Luzon is onion. Similar with other irrigation systems, the irrigation fee for non-rice crops is 60% of the equivalent irrigation fee for rice.

Onion was the most profitable non-rice crop, financially and economically. Onion production systems ranked high in Central Luzon. However, at the current level of the system's performance, economic and financial benefits from rice-onion cropping pattern showed that UTRIS cannot sustain the cropping pattern's financial and economic viabilities (Table 5).

Sensitivity analysis of rates of return. Results in Table 7 show that the estimated IRRs and BCRs were very low to justify additional investment costs for rehabilitation across systems and cropping patterns.

Table 7. Sensitivity analysis of internal rate of return (IRR) and benefit-cost ratio (BCR) for rice -- non-rice cropping pattern, after adjustments in rehabilitation costs, four national irrigation systems, Luzon, 1987.

System/Cropping	Financial		Economic	
Pattern	IRR(%)	BCR*	IRR(%)	BCR*
LVRIS				
Rice-Mungbean	5.87	0.38	Negative	
Rice-Peanut	11.28	0.72	Negative	
BP#2				
Rice-Garlic	6.19	0.50	2.17	0.27
TASMORIS				
Rice-Corn	Negative		Negative	
UTRIS				
Rice-Corn	11.57	0.54	2.01	0.30

* at 15% discount rate.

Summary and Conclusion

The economics of crop diversification and irrigation investment of four national irrigation systems were assessed. Cropping patterns evaluated were rice-mungbean, rice-peanut, rice-corn, rice-garlic and rice-onion. The four national systems analyzed were Laoag-Vintar (LVRIS), Bonga Pump No. 2, TASMORIS and UTRIS. The benefit cost ratio (BCR) and the internal rate of return (IRR) were used to determine the viability performance of each system. In the benefit-cost analysis, the financial and economic valuation was applied to assess the viability of irrigation investment at the system-level. In the financial analysis, the market prices actually encountered by farmers were used. On the other hand, in the economic analysis, border prices, i.e., the market price net of subsidies and taxes for inputs and border prices for outputs were used. The net financial profit (NFP) and net economic profit (NEP) of non-rice production systems were considered in evaluating the economic and financial viabilities of the four national irrigation systems.

Financial and economic analysis of the benefits and rates of return to irrigation investment on the four national irrigation systems with respect to rice-based crop diversification were very low. The low levels of benefits and rates of return across cropping patterns were attributed to high capital investment and high operation and maintenance costs. However, technical, agronomic, and institutional constraints must be taken into account before drawing generalizations on the desirability of irrigating non-rice crops (IIMI, 1986).

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Nestle Soya Farm's Perspective on the Potential of Soybean For Crop Diversification in Irrigated Areas

Alexander R. Madrigal [1]

Introduction

Soybean importation in the Philippines is a perennial problem since domestic' soybean production has not been sufficient to meet local demand. In 1983 alone, 30,555 tons of raw soybeans and 260,954 tons of soybean meal were imported to sustain the protein requirement of the poultry and livestock industries.

The pursuit for an import-free soybean industry has long been an unrealized dream in the Philippines. Since the 1970's, local scientists geared efforts to package technologies on soybean production adaptable to Philippine conditions. National soybean programs have been launched to boost production but were not successful. Development work were mostly initiated by government institutions. Since 1981, the Crops Research Division of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) has emphasized the research and extension situation. The development of crop production strategies and their integration with farming systems has been identified as one of the problem areas and recommended research activities.

Nestle Philippines, Inc.'s Interest in Soybeans

Nestlt Philippines had been providing quality food products for 77 years now. In 1978, it was the first private food manufacturing company ever to take serious interest and investment in soybeans. Banking on the premise that if soybean-based food products would be acceptable in the local market, then such product would be readily accepted in other developing countries.

It has been Nestles policy to procure the raw materials it needs from local farmers and other independent sources. This commitment is exemplified by its Agricultural Services Department's continuous research, development and extension activities providing technical assistance and support.

Raw materials for soybean-based products in Nestlé Phils were obtained from limited contract growers. Since 1979, the Nestlé Soya Farm at Crossing Rubber, Tupi, South Cotabato provided production services to soybean farmers in terms of technical and extension guidance, subsidized seed loan, pesticide loan and market assurance. Harvesting and post-harvest facilities were also made available at cost.

Soybean deteriorate rapidly especially under ordinary room storage. The need for fresh bean supply prompted Nestlt Soya Farm Management to investigate the potential of expanding its services to irrigated areas to meet its year-round demand, Tupi and most traditional soybean growing areas are rainfed and upland-based fanning. Numerous research reports had supported the potential of soybean in irrigated areas for crop diversification. Problems have been identified but solutions need further investigation.

Water Requirement of Soybean

The water requirement of soybean varies depending on location, season, variety, soil and climate. Generally, soybean requires more water to sustain an optimum yield compared with corn. Weiss (1983) stated that 600-1000 mm rainfall is required to produce 2,000 kg/ha of soybean seeds. Evapotranspiration is 13% higher in soybean than in sorghum for the same leaf area. There are

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* Area planted as of 7 September 1988. Average yield taken from 65 hectares harvested area to date.

assumptions that soybean requires 400 t/ha of water to produce 1.0 t/ha of dry matter (AVDRC, 1975). In instances where water is not limiting, 60% of soybean roots develop within the upper 20 cm soil layer. More than 80% of the water absorbed by the plant is being supplied by roots 40 cm or deeper. Planting in AVDRC dry season (January 1975), revealed that it is possible to obtain high soybean yields if sufficient water is applied initially for germination. The highest yield was 3.1 t/ha, harvested on 13 May. Total rainfall during the experiment was 117 mm which fell mostly in late April and early May. The average evaporation rate was 5.4 mm/day. About 200 t/ha of water was applied after planting to ensure good germination. Apparently 3,200 t/ha of water was obtained from the soil even in the middle of the dry season by capillary action

In tropical regions, two to three well-timed irrigations is usually necessary (FAO, 1961). In Nebraska, maximum yield per unit of water was achieved after starting with the soil at field capacity and irrigating once just before flowering. The amount of moisture a soybean crop uses throughout the growing season is shown in Figure 1. Soybean uses relatively little moisture at planting and shortly afterwards. However, it is profitable to irrigate within a few days after planting in coarse sand because of the soils' less water holding capacity. If moisture loss delays germination and the onset of vegetative growth, yield may be reduced (Superior Soybean Production, Circular 1200). For high yields, ample vegetative growth especially in leaf area is required. Plant types that have reached 40 cm or more at flowering would have adequate vegetative size to support high

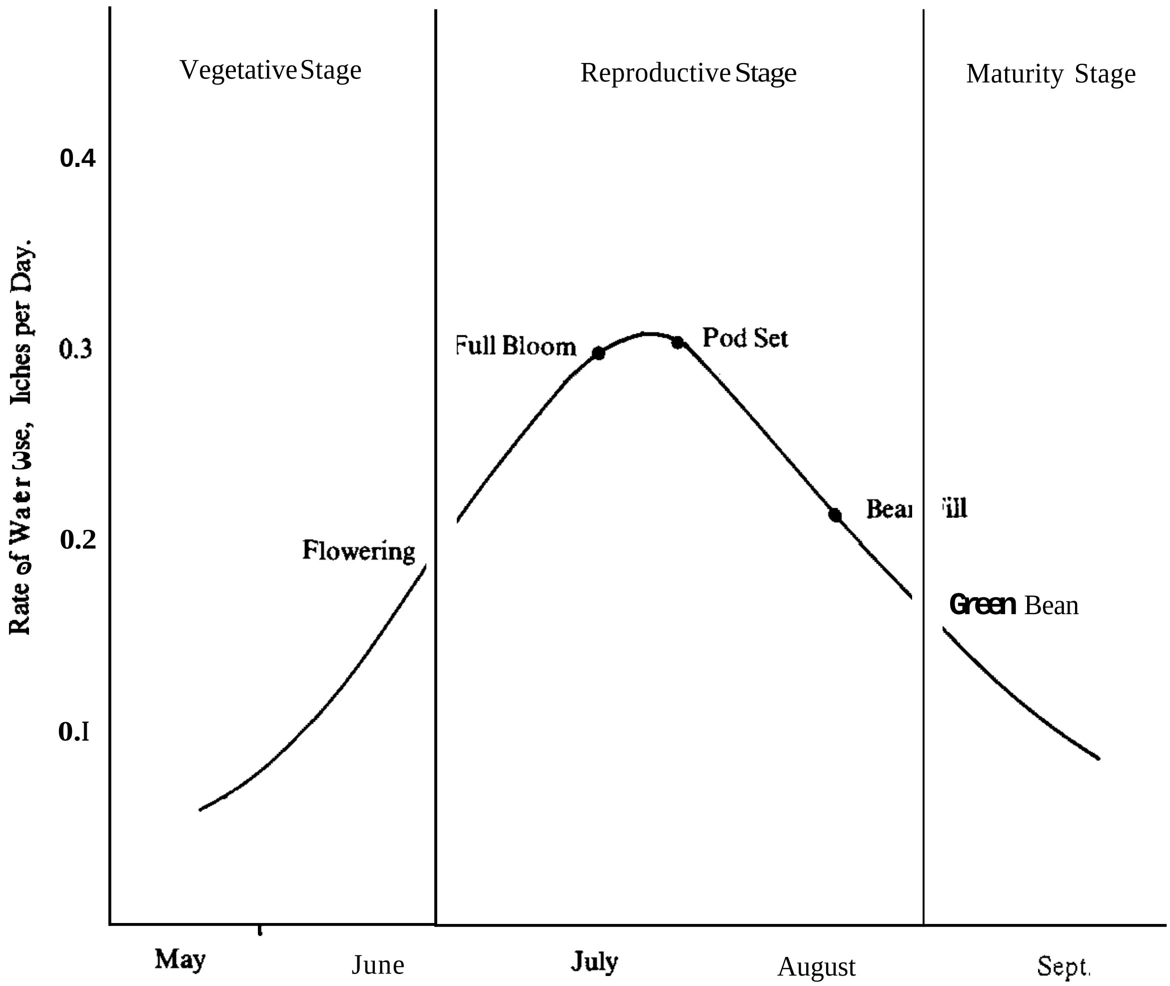

Figure 1. Amount of moisture used by the soybean crop throughout the growing season adapted from Soybean Handbook, Cooperative Extension Service, Kansas State University.

reproductive growth (AVDRC Soybean Report, 1975). Of the 500-760 mm of water that soybean uses, 60-70% is required from 40-100 days after emergence. There should be enough moisture throughout this stage to promote steady, rapid growth of vegetation (Superior Soybean Production, Circular 1200). Plant canopy should be fully developed by pod set to intercept the maximum amount of light and prevent further evaporation of residual moisture. Determinate varieties will more likely require irrigation during vegetative period. They are less tolerant to moisture stress and cease vegetative growth when flowering begins. During flowering, soybean can recover better than corn from moisture stress because of its longer flowering period. Under the best conditions, only a fourth of the flower set pods. But in severe moisture stress, pod abortion can still occur. Results of research conducted by IOWA State University indicate that as few as four consecutive days of visible moisture stress during the pod set and bean filling stages can reduce soybean yields to as much as 40% (Figure 2). Irrigation should therefore be sustained late enough to prevent serious moisture stress until the leaves begin to turn yellow.

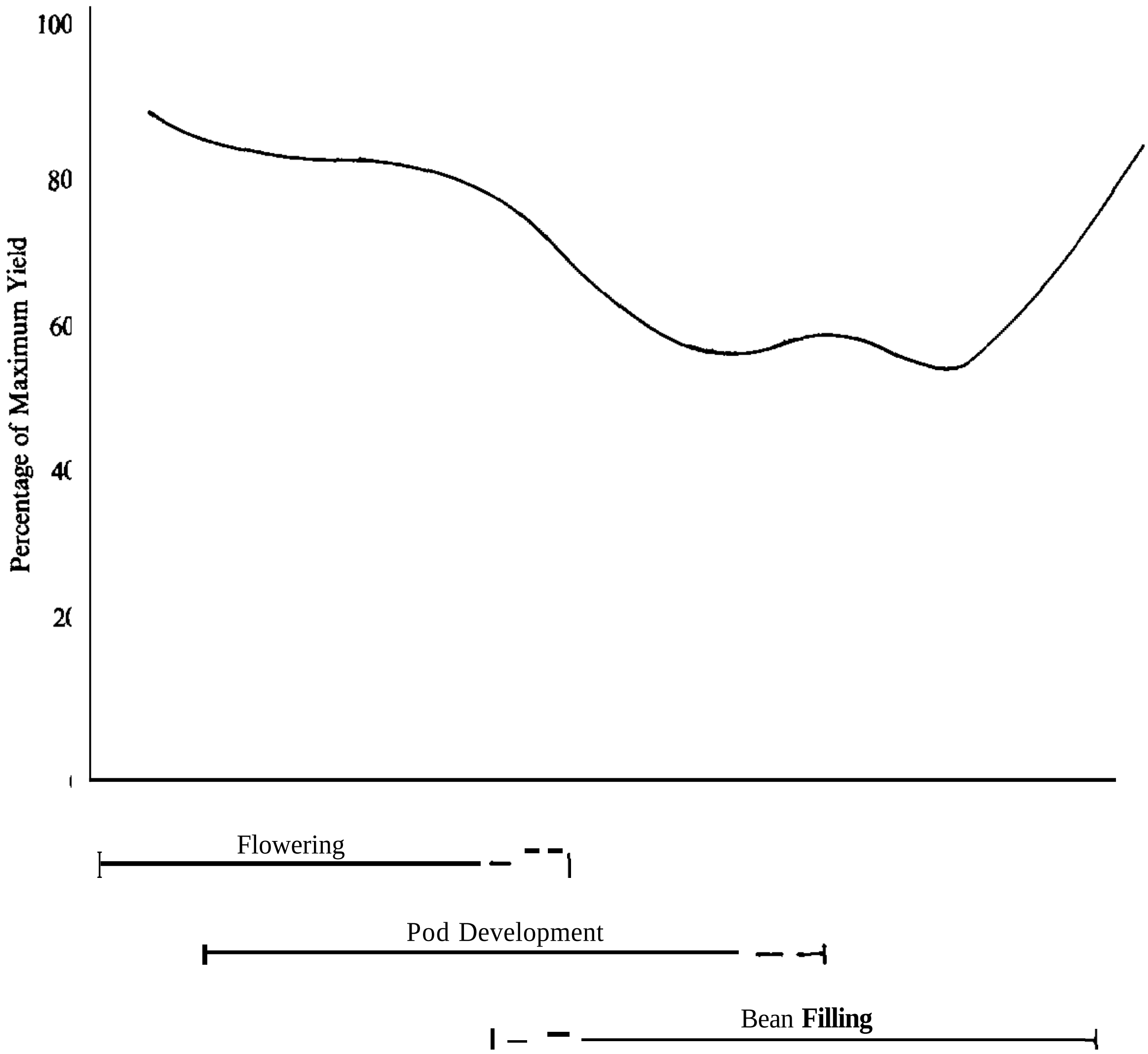

Figure 2. the effect an soybean yield of visible moisture stress symptoms. Moisture stress can have an especially serious effect during late pod development or early in the bean filling stage, reducing yield by as much as 4° percent (adapted from R.H. Shaw and D.R. Laing, "Moisture Stress and Plant Response," in Plant Environment and Efficient Water Use).

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Soybean Production Areas and Status

Rainfall Pattern

Soybean production in Mindanao is dependent on rainfall. Majority of soybean areas are rainfed. Irrigated areas are seldom devoted to soybean production. Figure 3 shows the rainfall pattern of some soybean producing areas. San Miguel, Surigao del Sur, with a potential of 800 hectares for soybean, has only one cropping season per year. Planting starts from March to June. Heavy rainfall between October and February limits the cropping to only one per year. The same situation exists in Mati and Cateel, Davao Oriental. Tupi, South Cotabato has a potential for two regular croppings i.e. April to June and August to October. Banga and Surallah, South Cotabato have relatively lower rainfall during most of the year. Two croppings are possible but a lot of areas are served by irrigation systems. Trial plantings of soybean after the dry season rice crop has been initiated in these areas since 1984. Problems identified were water scheduling, planting schedule in relation to regular rice cropping, farmers' technology on soybean production, financing and quality.

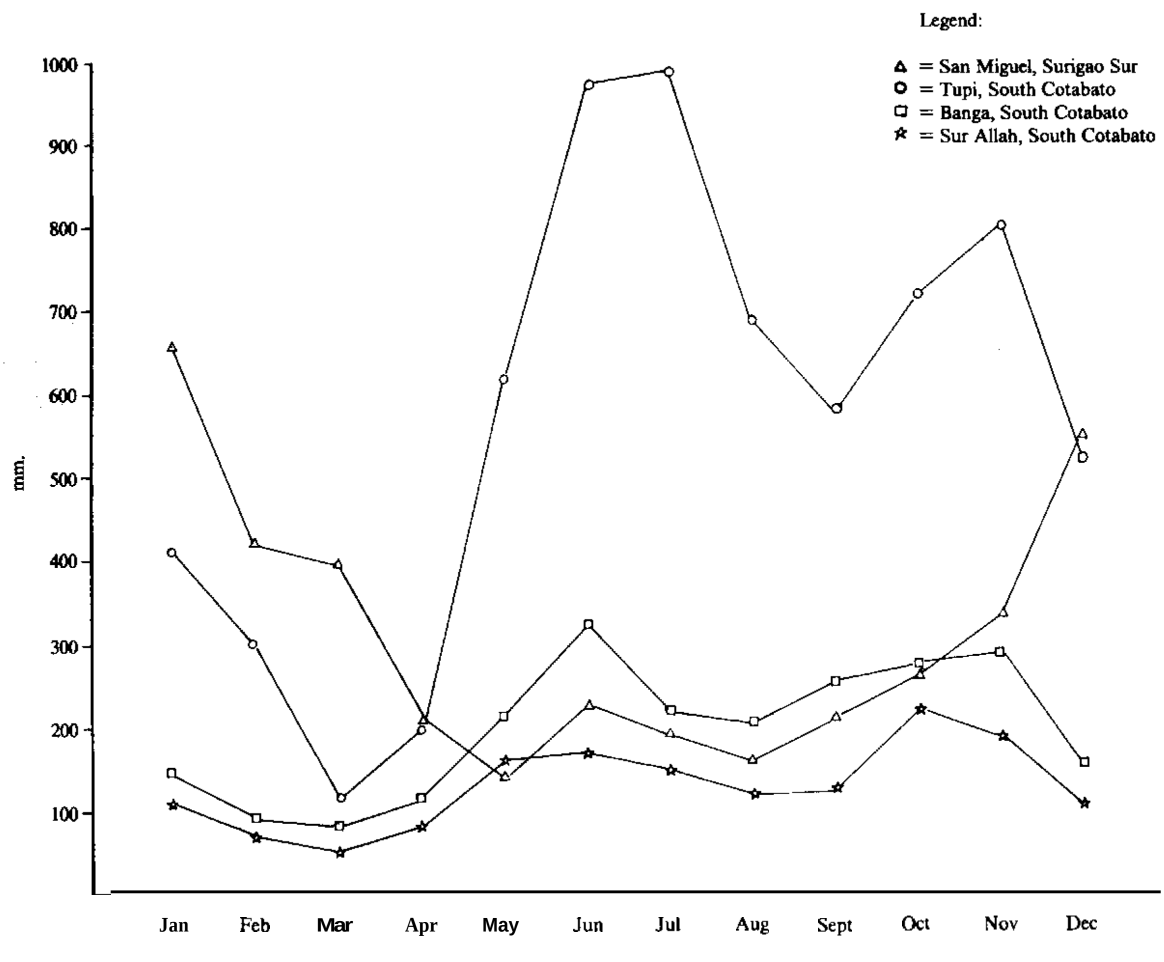

Figure 3. Monthly rainfall pattern of some soybean production areas. (Average 198 -87).

Table 1. Soybean production data at Nestlé Soya Farm, 1984-1988.

	1984	1985	1986	1987	1988'
Area planted (ha)	163	438	200	310	292
No. of cooperators	123	255	162	246	222
Ave. area per farmer (ha)	1.3	1.7	1.2	1.2	1.3
Ave. yield (kg/ha)	0.8	0.9	1.12	1.09	1.32

*Area planted as of 7 September 1988. Average yield taken from 65 hectares harvested area to date.

Table 2. Monthly average yield (kg/ha) and area planted from 1986-1988, Tupi, South Cotahato.

	January		February		March		April		May	
	Yield	(ha)	Yield	(ha)	Yield	(ha)	Yield	(ha)	Yield	(ha)
1986	939	9.0	1902	3.0	1653	1.2	1071	1.5	1439	46.0
1987	1351	2.8	547	3.0	390	0.5			1354	32.6
1988	1183	2.0	1215	3.6	631	7.0	1534	28.8	1135	26.6
Ave.	1158	4.6	1221	3.2	891	2.9	1302	15.2	1244	35.1

Crop Performance

Table I shows that soybean yield per hectare increased gradually from 1984. Intensive varietal development and technical assistance coupled with active extension support were the reasons for such an increase over the national average of 0.88 t/ha. The number of farmer-cooperators and hectarage varies from season to season and from year to year depending on raw material requirements for soybean products and farmgate price of soybean relative to other cash crops.

Table 2 shows that planting was done between **January** and March. Although there were differences in monthly averages for three years, planting in January and February gives higher yield than in March. Upland areas planted in January and February are in Tampakan and Banga, South Cotabato (ranging from 5-10 hectares) with irrigation systems that utilize three to four flush flooding during the entire growing season. Plantings in March in Surallah, South Cotabato are mostly in lowland irrigated areas after a rice crop. However, the crop was given only one to two flush-flood irrigation, hence, the low yield. Moreover, harvesting of the crop planted in March coincided with the rainy month of June creating post-harvest problems and quality risks. However, it is evident that with enough water supply, soybean planted outside the normal wet and dry season cropping is feasible. together with technical training of the farmer on the improved practices on soybean production. November-December planting has not yet been investigated in South Cotabato. Proper choice of non-photoperiodic varieties and planned on-farm variety trials in target areas will be very beneficial. A variety identified to be suitable for lowland rice-based cropping system was UPL-Sy2. Nestlé Soya Farm will still be very active in expanding its production services to potential irrigated areas to satisfy its fresh bean requirements all year round.

Conclusion

The data presented were micro in scope and achievements but they indicated the potential of soybean as an alternate for crop diversification especially in irrigated areas where water supply is less than what is required for rice. However, planting date should be carefully planned in connection with the cropping pattern so as to avoid harvesting during the rainy months. Water supply and scheduling should be properly programmed

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Guidelines for Production and Irrigation Management of Selected Upland Crops

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Introduction

Crop diversification has been a rudimentary practice among farmers in the Philippines, especially in relatively dry regions where rainfall is the main source of water for crop production. In some cases, farmers devise simple irrigation systems. They build temporary brush dams to divert part of the streamflow from nearby rivers or drainage channels.

Crop diversification is popular among farmers in the dry regions of northern Luzon, in the provinces of Nueva Ecija, Nueva Viscaya, Batangas, Cavite, arid in a few areas in the Visayas and Mindanao. Majority of them are subsistent farmers who cultivate small patches of lands. They informally learned diversified cropping through trial and error in an effort to produce more to sustain their food requirements. However, crop diversification has not been documented until recently.

'This paper discusses "Guidelines for production and irrigation management of selected upland crops", a project of the International Irrigation Management Institute (IIMI). Corn, mungbean, garlic and onions which are the major diversified crops grown in the Ilocos Region and Nueva Ecija are discussed. IIMI has targeted these crops in its applied research on crop diversification in irrigated areas with deficient water supply during the dry season.

Concept and agro-climatic setting for crop diversification

Irrigated areas which experience deficient water supply during the dry season are potential areas for crop diversification because of: (I) the need to maximize production by proper utilization of the available irrigation water during the dry season; (2) the chances of enticing active cooperation among farmers are greater than in strictly rainfed areas; **(3)** the opportunity to pilot-test and demonstrate innovative technology packages on crop diversification is more promising since the situation allows for a wider latitude for planning in terms of time and space and; **(4)** the general program of the government to concentrate countryside development in areas with existing infrastructure. The move to irrigate non-rice crops is a step toward institutionalizing the adoption of crop diversification technology. Relevant information on crop diversification is expected to be generated from research, pilot-testing and demonstration activities.

The Role of Water in Diversified Crop Production

Knowledge of soil-plant-water relationship is important in crop production, specifically in crop diversification. 'The study of soil-water relationship in crop production has given birth to what **is** now commonly known as *water* ***manugemenr*** or ***irrigation*** *management*. Water management **is** defined as the judicious and rational application of irrigation water in order to promote an optimum environment for plant growth and development.

Because of increasing scarcity and expensive use of water, it is important to practice water saving methods and irrigation schemes. Water conservation makes possible larger areas to be served or the extension of cropping periods during the dry season. On the other hand, improper irrigation results in wastage of water and loss of soil nutrients by leaching, resulting to impaired land productivity and decline in crop yields.

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In crop production water is used in many ways: (I) it keeps the soil in good tilth for efficient tillage operations; **(2)** it facilitates plant root penetration; **(3)** it dissolves soil nutrients for efficient absorption by the plant; and **(4)** it regulates soil temperature and maintains an efficient exchange of gasses between the atmosphere and the root zone.

Land preparation in dry agriculture using tillage equipment is possible only if soil moisture **is** slightly below field capacity. Therefore, farmers have to schedule the last or terminal irrigation.

Terminal irrigation should be applied when the standing crop **is** about **to** be harvested; the level of residual soil moisture will then be ideal for immediate plowing and harrowing in preparation for the next crop. Unnecessary and costly delays in planting will also be avoided.

If terminal irrigation is applied too late, the soil may still be wet for land preparation and hence, a drying period will be required. Each day spent to dry the field is time lost. Water which evaporated while drying the land is **also** considered a waste. If applied too early on the other hand, the soil may most likely undergo excessive drying before the scheduled harvest. Under such a case, the standing crop might dry up prematurely and adversely affect the quantity and quality of the produce. Moreover, substantial amount of water might be needed to replenish part of the evaporated soil moisture to a level that is optimum for tillage operations.

By maintaining enough water at the rootzone, the plants can develop healthy and vigorous roots whichcanpenetratedeeperand widerinto the soil. Soil which can enhance root development is an important consideration in crop production especially in dry areas where groundwater source proximate to the active rootzone exists. In such a case, crops have greater chances to succeed even if irrigation water is limited at the end of the cropping season.

Water facilitates absorption of soil nutrients. Soil nutrients in the form of soil solute are needed to sustain turgidity and photosynthesis for plant growth. Ideally, the level of soil water must be maintained at the upper 50% of the capillary range. This enables the roots to provide the water demand rate of the crops. During hot and windy days, plants exhibit temporary wilting due to high evapotranspiration. Farmers should then monitor the soil moisture level regularly ***so*** that the soil does not become excessively ***dry*** before the next irrigation is applied.

Water has a larger capacity to transmit and store heat than soil. Taken separately, a volume of water will neither warm up **as** rapidly nor attain **as** high a temperature **as** an equal volume of dry soil. When taken together, water plays the important role of regulating soil temperature. When the soil gets too dry, absorption of water and nutrients by the roots become increasingly difficult and the advective heat emitted from the dry soil surface causes plants to wilt resulting in **loss** of turgidity, stunted growth and reduced yields.

Soil Moisture Constants

In developing alternative irrigation management strategies vis-a-vis crop diversification, planners should understand the nature of **soil** moisture storage.

The soil's capability to store water depends **on** the texture and aggregate structure of soil particles. About 40-60% of the pore space between the soil solids can hold water while the remaining pores are **for** aeration and drainage of excess water. This proportion of air-water in the **soil fits** well with the requirements of most upland crops. When upland crops are grown with lowland rice under a crop diversification scheme the upland crops should be planted in welldrained soil.

In planning the alternative irrigation management strategies, planners should be familiar with the following:

Saturation is a condition where all pore spaces between **soil** particles below the **soil** surface are filled with water. A small volume of air **is** contained in saturated soils, which can be immediately depleted by **soil** microorganisms. Saturated soils are suitable only for lowland rice.

Field capacity **is** the amount of water or soil moisture retained after draining saturated soil. Each soil particle is completely surrounded by a relatively thick film of water. However, soil water are in the form of wedges between soil particles. It is through these wedges that plants absorb water.

Moisture is held in the soil against the pull of gravity. **Thus,** plants expend some energy (suction energy) to enable them to extract the soil water. At field capacity, the energy required is about one-third atmosphere (an equivalent tension force needed to raise a column of water to a height of 300 cm) in clay soil and about one-tenth atmosphere in sandy soil.

However, the energy needed to extract water from the soil increases rapidly than the corresponding decrease in soil moisture. The roots must satisfy such energy expense but only to a certain limit. Beyond such limit, the residual moisture is tightly attached to the soil particles and the corresponding energy needed for its extraction is beyond the normal absorptive capabilities of the plants.

Permanent wilting point. Continuous removal of water by plant roots causes gradual thinning of the soil moisture films around the particles and most of the wedges of water between particles disappear. A situation will eventually be reached when water is tightly held by the soil particles. The roots will not be able to extract it at a sufficiently rapid rate to prevent irreversible wilting. At this level, the energy required to extract water from the soil is about 14-15 atmosphere or equivalent to a tension force needed to raise a column of water to a height of about 1590 cm.

Unusual wilting or drooping of the leaves early in the morning and late in the afternoon indicate that soil moisture has decreased to the level or at least near the permanent wilting point. Some plants, however, will not show signs of wilting but will exhibit other signs such as change in the color of the leaves *or* stem and decreased plant and fruit growth. In practice, it is very difficult to determine the exact soil moisture level at which plants wilt. Therefore, permanent wilting point concept should be used only as a reference. Permanent wilting point is the limiting moisture wherein plants are irreversibly wilted because of excessively low soil moisture content. In general, the soil moisture content (dry mass) is about 12 to 18% in fine-textured and **10%** or less in sandy soils.

Available soil moisture. The soil moisture content between field capacity and permanent wilting point determine the limits of capillary water. This is the form of moisture that is retained in the soil unless absorbed by the roots or lost through evaporation. It is called capillary water in the sense that it moves through the soil by capillary action whenever any two points in the soil differ in energy potentials. In practice, the upper 50% of the capillary water range (from field capacity to permanent wilting point), is generally considered as available water for plant use. This limit prevents plants from being unduly exposed to frequenl soil-moisture deficits because their effects are usually cumulative. If water is inadequate, the plants may be allowed to deplete the soil moisture to as low as 75% of the capillary water range. This practice is allowed only as a strategy to save the crop when water is very limited, especially during critical growth stages.

At saturation, water occupying the large pores will be removed by gravity. Water at field capacity will be removed by direct evaporation and absorption by the roots. Sandy soil exhibits lower moisture content and narrower margin of difference between field capacity and permanent wilting point than clay soil. Clay soil can hold more water than sandy soil. Although clay soil generally exhibits slightly higher moisture at field capacity than loam soil. some clay soil exhibits much higher moisture at permanent wilting point than loam soil. Thus, some clay soil has less capillary or available water storage. This happens when clay soil contains more fine clay than either sand or silt particles and/or high organic matter which tends to seal the fine pores. Therefore, the following factors affect retention and movement of soil water: (1) soil porosity and pore size distribution as influenced by grain size distrihution and the aggregate structure of particles, (2) soil depth, (3) cation exchange capacity of the soil, (4) soil temperature, (5) soil organic matter content and (6) quality of the soil-water system.

Irrigation Methods

Typical irrigated areas such as those served by gravity systems in the Philippines normally exhibit different land features within their respective commands. Moreover, individual farms or fields within a command may exhibit differences in terrains (i.e., uniformity and gradient, soil fertility, soil depth, soil texture and structure, etc). Methods of irrigation must be suited depending on topography, the crops planted and availability of water sources.

Current efforts aim to entice more farmers to practice crop diversification after the wet season rice crop. Since the same rice fields (rainfed or irrigated) will be planted, a number of surface irrigation methods are described as follows:

Level borders and basin irrigation. lrrigation by basin method is done by applying water to a level plot surrounded by dikes or levees. It is especially adapted in nearly level lands (as in lowland rice paddies) and may be used to irrigate a wide variety of soil texture and crops. This method is particularly suited for fine-textured soil with low permeability where it is necessary to hold water on the surface in order to insure adequate infiltration.

Level borders or basins, may vary in shape and size. During irrigation, basins are filled with water to a predetermined depth that will sufficiently refill the storage reservoir of the soil.

Contour levee ***irrigation.*** Irrigation water is applied to nearly horizontal areas confined by levees constructed following contour lines. This method is usually used in areas where slope is greater than **0.20%** but not higher than **4.0%** and where levelling would be impractical and expensive. The distance between levees depends on slope and crop to be irrigated. Difference in elevation between adjacent levees range from **3-15** meters. The contour levee method is well suited to lowland rice and any crop that can tolerate flooding for 12 hours or more. Irrigation water must be available at high flows in order to allow enough flooding of the area. Good drainage facilities must also be provided to drain excess water.

Contour-levee irrigation maximizes the use of rainwater. High efficiency can be achieved by this method provided the soil is not porous.

Contour ditch irrigation. Controlled flooding from field ditches running along the contour allows water to flow down the slopes between adjacent field ditches without employing dikes or other means to guide or restrict its movement. The field ditches should be spaced fairly close to each other in order that the irrigation water can be applied uniformly. Frequent ditch-checks, spreader furrows or siphons in the ditch are needed for uniform distribution of water. The contour ditch method is often used for close-growing crops such **as** pasture crops. It is also ideal for sloping and rolling lands which cannot be easily levelled.

Furrow irrigation. Crops planted in rows such **as** corn and vegetables can be irrigated by the furrow method. Water is applied in the furrows which are made by cultivating the spaces between the plant rows. Furrows usually run directly down the dopes, but can also run on the contour (basin furrows) to control erosion. Furrows may also be established across the slope for a rectangular and for uniform row length. Spacing between furrows depends on the crops planted. When irrigating, water must not overflow so **as** to minimize the breakdown of furrows.

Furrow irrigation is adaptable to a wide variation of slopes and soil textures. This method can be used with either large or small streams of irrigation water because water can be directed into any number of furrows directly from a farm ditch (or field) or gated pipe. The soil in the furrow is generally **loose** from cultivation and, therefore, care should be employed to control the flow of water in the furrow so that it does not develop an erosive velocity.

Excessive water losses will occur from deep percolation if the furrows are too long. The initial stream should be large enough to run through the furrow rapidly without erosion but should be reduced to minimize tailwater runoff **as** irrigation progresses.

Furrow irrigation is also used by farmers to irrigate crops planted on raised beds or ridges on nearly level lands similar to a lowland rice field. The beds or ridges are made by either plowing the land to form the beds or making deep furrows in the tilled land. It is best suited to irrigate garlic, onions and certain species of vegetables.

Corrugation irrigation. Shallow furrows running down the **slope** from head ditches or lateral canals are called corrugations. Corrugations are used to irrigate close-growing crops like bean crops, garlic and onions. The water flows laterally through the soil, between corrugations. This method is used in fine-textured soil that absorb water slowly and on lands that are moderately steep and irregular. Corrugations are also established on soil which seal over and crust when flooded.

The spacing and size of the corrugations vary depending on the crops. Generally, closer corrugations are established in more porous soil to prevent excessive deep percolation losses. Length of corrugation depends largely on soil type and **slope.** Lengths should be short enough ***so*** that the upper end of the field would not he over-irrigated by the time the lower end receives sufficient water. Corrugations are often used to establish perennial crops on border strips.

There are other irrigation methods available but were not included in the discussion. The methods enumerated above are the most likely methods to be used in crop diversification in typical lowland ricefield. The other methods are more complicated and expensive **for** ordinary farmers.

Crop production and irrigation management

The yield potential of a crop is determined by its genetic characteristics and its adaptability to actual field conditions. Crops differ in soil. water, solar radiation and other climatic requirements for optimum growth and yield.

Temperature determines the rate of crop development and hence, length of total growing period. Some crops have specific temperatures and/or daylength requirements for initiation of growth and development. Furthermore, the quality of yield in some crops is influenced by temperature.

Crop growth and yield are affected by the total radiation received. At a given radiation and temperature, crops differ in their abilities to convert the total radiation received into yield. This difference has an important effect on how efficiently water can be utilized for crop production.

The amount and availability of water during a cropping season also affects crop production. Crops differ in their requirements too. As much as possible, the demand for water must be synchronized with its availability. However, demand and availability of water is difficult to synchronize because the latter is beyond human control specially during the dry season. Thus farmers have to consider the availability of water when planning their planting schedule.

The production and irrigation management required for corn, mungbean, garlic, and onions will be discussed. It is hoped that these guidelines can help researchers and extension technicians and the farmers how to improve their technical management skills.

Corn

Corn is an important crop both as food for man and feeds for animals. In the Philippines, about 25% of the population eat corn.

Corn can be grown under a wide range of climatic conditions provided that the mean daily temperature is above 15°C and frost-free. A successful corn crop depends on variety planted.

Planting and ***cultural management.*** Corn is planted in rows. Seeds are either sown manually or drilled along the rows. The average planting distance is 15-20 cm between hills and 50-75 cm between rows. Ideal population density ranges from 60,000-100,000 plants per hectare.

Two weeks after emergence, the plants are hilled-up to remove weeds and establish the irrigation furrows. Fertilizer may be sidedressed during this time by scratching the side hills with a hoe or pointed stick to create corrugations. The fertilizers applied must then be covered with soil to prevent wastage when irrigation is applied.

A second weeding and hilling-up operation is done usually about four to five weeks after emergence. This may be accompanied by another round of fertilizer application.

Corn performs well in moist soils but less in heavy clay and sandy soils. The soil should be well-aerated and welldrained since corn is susceptible to waterlogging. If the soil is saturated or flooded for more than 24 hours, the plant may be physiologically disturbed as may be shown by discoloration of the leaves. If the excess water cannot be evacuated soon enough, plant growth will be stunted because of the absence of oxygen in the rootzone.

Corn is a high nutrient-consumer, requiring 200 kg Nitrogen (N), 60-80 kg Phosphorus (P) and 60-100 kg Potassium (K) per hectare. Unless adequate fertilizer is applied, it is not advisable to plant another crop of corn immediately after the first crop. Instead, leguminous plants should be planted to replenish soil nutrients.

Irrigation requirements and water management. Furrow irrigation is the usual method of irrigation for corn. Under ordinary conditions, an evapotranspiration rate of 5-6 mm/day is a safe estimate of the rate of soil moisture depletion. Irrigation interval is determined by dividing the depth of available water by the evapotranspiration rate.

It is good practice to synchronize fertilizer application with irrigation schedule. Also, the amount of irrigation water should be predetermined to avoid wastage of both nutrients and water, either through deep percolation or tailwater runoff at the end of the furrows.

In corn production, water must be available especially at flowering stage although corn can tolerate drought conditions at vegetative and after ear formation. The amount of irrigation is gradually reduced as the plant matures.

Under conditions of marginal rainfall and limited irrigation water supply, the number of irrigation schedules may vary from two to five depending on the severity of the water deficit. Therefore, irrigation schedules should be planned to take into account various growth stages of the plant.

Mungbean

Mungbean is grown primarily for its seeds. It thrives well in areas with medium rainfall. During the dry season, the crop can grow favorably provided that, there is enough water.

Planting and cultural management. Excessive rainfall and hot climate results in shattering of flowers and pods as well as increase in the incidence of pests and diseases. The optimum daily mean temperature for mungbean ranges from 15-20°C. The minimum and maximum temperature are 10°C and **27°C,** respectively.

Mungbean can be grown in any type of soil, however, friable and semi-acidic (pH 5.5-6.0) are preferred. For optimum production, 20-40 kg-N, 40-60 kg-P and 50-120 kg-K are applied per hectare. Although, mungbean is capable of fixing nitrogen, applying fertilizer at sowing will stimulate early establishment of the young plants.

Mungbean can be planted in two ways - broadcasted or drilled. Regardless of the planting method, plant population should be maintained at about **250,000-300,000** plants per hectare. Mungbean is usually planted as seeds or pre-germinated seeds a few days before or soon after the rice crop is harvested. Rice straw which is usually left in the field are pressed to the ground to serve as mulch to control evaporation of water and regulate soil temperature during early plant growth. On the other hand, mungbean is drilled if the field is cleared of plant debris. With zero tillage, a pointed wooden stick is used to dibble holes on the ground at random. Holes are dibbled 20-25 cm apart, with 2-3 seeds/hole. The residual soil moisture may still be able to permit emergence of pre-germinated seeds.

If residual soil moisture is low, it is better to plow and harrow thoroughly, then construct furrows. Mungbean are then drilled at the top or below the furrow ridge as in the case of corn. Distance between furrows ranges from 3040 cm while distance between hills ranges from 10-15 cm. First irrigation is applied after sowing.

When imgating mungbean, water supply should be strictly controlled. Weeds, pests and diseases should also be controlled. Thinning must be done to maintain the ideal plant population; dead plants must be replaced otherwise.

Irrigation requirement and water management. Mungbean is relatively a dry crop, requiring only about 200-300 mm of water. It cannot tolerate high soil moisture especially during seeding and establishment stages. Imgation can be applied by flooding in the case of broadcasted or drilled mungbean seeds without furrows and by furrow irrigation for furrow-seeded plants.

Where flooding is used, it is a good practice to construct deep trenches at each side of the field to drain excess water.

Water supply should meet the water requirements during crop establishment and flowering periods as these are critical stages. Plants subjected to water stress have dark blue leaves. As a guide, an evapotranspiration rate of 4.0-5.0 mm/day is sufficient to produce a good crop of mungbean.

Mungbean is shallow-rooted. Its fibrous roots are distributed within the rootzone at 0.50-0.70 meters deep. With adequate water supply, frequent irrigation is necessary.

Garlic

Garlic, a bulb crop is known for its varied uses in food preparations and medicine. Garlic is the most profitable dry seasoncropin northern Luzon particularly, in the provinces of Ilocos Norte and Ilocos Sur.

Garlic grows on various soil types but can perform best in sandy loam to silt loam soils. The soil should be fertile and welldrained but capable of maintaining adequate soil moisture during the growing period. Poorly-drained soils retard bulb formation. Since garlic is usually planted after rice, deep drainage ditches should be constructed on both sides of the field to drain excess water. Ditches are indispensable in fields within the command of an irrigation system.

The optimum soil pH for garlic is about 5.5-6.5.

Planting and cultural management. Land preparation for garlic can be done with or without tillage. With tillage, the field is plowed twice at 7 day interval. Each plowing should be followed by two harrowing operations. Land preparation using a rotavator is also applicable, depending on the density of weeds.

Without tillage, garlic is immediately planted after plant debris and stumps from the previous crop have been removed. If the previous crop is rice, straw and weeds are cut close to the ground. If the field is saturated, it should be dried to about field capacity before planting the seed materials which are then covered with mulch. Some farmers mulch and dry the rice field before seeding. The ideal time for planting garlic is in early October to November. Seed cloves are soaked for one hour in pesticide solution before planting.

Garlic is dibbled into the soil using a pointed stick. Depth of planting is 2-3 cm. Planting distance ranges from 20 X 20 cm to 25 X 25 cm, depending on soil fertility. To assure good soil-clove contact, the soil is pressed around the cloves using the thumb and forefinger.

Fertilization should only compensate the native fertility of the soil. In Ilocos Norte, the recommended rates of fertilizer applications are: 90 kg-N, 60 kg-P and 60 kg-K per hectare for sandy soil; 80 kg-N, 60 kg-P and 60 kg-K per hectare for clay loam soil and 80 kg-N, 30 kg-P and **30** kg-K per hectare for clay soils.

Once planting and mulching have been completed, it is necessary to monitor the germination and emergence of the plants. Dead seeds should be immediately replaced. The mulch should not obstruct the emerging shoot.

Weeding should be regularly done to avoid competition for nutrient and water between crop and weeds. Emergence of pests and diseases should be immediately checked. Severely infected plants must be pulled and burned to avoid spread of the disease.

Irrigation requirement and water management. Garlic requires about 200-400 mm of water during the duration of its growth. Irrigation is applied by flooding the field at regular intervals since the crop is sensitive to wet environment. Excess water should be removed by trenching along the inner sides of the dikes. It is a common practice to irrigate garlic with **5** cm of water every two weeks, starting at planting until about 85 days afteremergence. Some irrigation schedules may be suspended, especially during periods of limited water supply. A modified version of furrow irrigation can be used provided that garlic is planted on 1.5-2.0 meter wide raised-bed. Since water is applied to the trenches between beds, it reaches the rootzone by capillary action.

Onions

Onion is another profitable dry season crop in the Philippines. Like garlic, it is planted after wet season rice. It has a variety of uses for food seasoning and for the manufacture of medicines.

Planting and cultural management. Bulb onion is grown from seeds. There are a number of improved varieties that are presently grown commercially, specially in Nueva Ecija.

Onion grows best in friable, fertile and well drained soil. Loamy soil with a pH of 5.5-6.5 is ideal for onions. Onion also grows best in cool weather during the early stages of growth and a comparatively dry atmosphere (with high temperature) during maturation. The crop is planted from October to December when the soil still retains a considerable amount of residual moisture from the previous rice crop.

Land preparation for onion is similar to that of garlic except that most farmers grow it in raised beds for better control of soil moisture at the rootzone.

Onion is first grown in nursery beds for about 6-7 weeks, and after which, it is transplanted to the field. Planting distance is **25** cm X **25** cm. About **3-5** kg/ha of seeds are needed to cover one hectare, i.e., depending on percent germination.

Bulbs are dibbled into the soil at 1-2 cm deep using a bamboo stick. Field/plots planted to onions are mulched. A moderate amount of water is applied directly to the plants to prevent wilting. An alternative is to irrigate the mulched field **3-5** days before transplanting. Extreme care should be exercised while planting the seedlings so that the soil does not become compacted.

Fertilizer requirement and fertilizer management is similar to that of garlic. Weeding, pest and diseasecontrol measures should be observed properly.

Irrigation requiremenr and water managemenr. Onion is sensitive to water deficit especially during transplanting, bulb formation and development. For high yields, soil water depletion should not exceed 25% of the available water. When the soil is relatively wet, root growth is reduced which favors bulb enlargement. Irrigation should be discontinued as soon **as** the bulbs are fully developed to desiccate the plant tops and prevent the formation of new roots. For optimum yield, onion requires about **300-400** mm of water during the growing season. Rapid bulb growth occurs at about 60 days after transplanting. At vegetative stage, the crop is less sensitive to water deficit. Controlled and frequent but light irrigation throughout the growing period is best for the crop to achieve high yield. Over-irrigation. leads to reduced growth. Irrigation can be terminated **15-25** days before harvest.

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Proposed Guidelines for the Management and Operation of Irrigation Systems with Diversified Cropping

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Introduction

Irrigation will remain as a critical factor in increasing food production in the Philippines. As such, it draws major fractions of the development investment resources of the country.

There are three approaches to help solve the problem of reduced economic return from irrigated rice lands: (1) increasing the economic yields of rice per unit area; (2) increasing the area served by irrigation systems through more effective and efficient irrigation management; and (3) introduction of higher value crops than rice.

The introduction of non-rice crops in irrigated rice areas may offer an opportunity to increase productivity, especially on areas which cannot support more than one rice cropping because of inadequate water supply. However, the introduction of non-rice crops in irrigation systems designed to irrigate rice complicates the existing irrigation systems operation and management procedures.

Improving irrigation systems management for rice and non-rice cultivation has been a major thrust of the International Irrigation Management Institute (IIMI), particularly in the Philippines where it has been implementing crop diversification studies since 1985 in collaboration with the National Irrigation Administration (NIA). Results of these and other related studies may now be used to modify existing NIA procedures not only for irrigated rice but also for diversified crops in rice-based areas.

The guidelines discussed herein will provide the basis for formulating procedures for water allocation and distribution for rice and non-rice crops especially during the dry season. It attempts to improve and supplement the procedures in the existing NIA Operations and Maintenance (O&M) plan and the Irrigation Management Information System for Monitoring and Evaluation (IMIS), particularly for irrigation systems suitable for diversified crops during the dry season. The guidelines focus primarily on how irrigation systems operation and management are planned and implemented, as well as the indicators used in monitoring and evaluating the system's physical performance and the analysis that will help in identifying the constraints and opportunities for improvement of the system.

Data from the Laoag Vintar River Irrigation System (LVRIS) were used to represent systems with distinct dry and wet seasons and from the Allah River Irrigation Project (ARIP) to represent systems with relatively evenly distributed rainfall pattern.

Adjustments will have to be made in the data used in the computation (i.e., seepage and percolation, rooting depth, crop growth duration, rainfall pattern, etc.), if this procedure is to be applied in other systems. These adjustments will hopefully enable the accommodation of location-specific information and data which will be used in making appropriate estimates of actual water use during the dry season.

It is expected that NIA will comment on the guidelines for further improvement and to adopt those appropriate and make them part of its operational procedures in managing irrigation systems for diversified cropping. The procedure will be tested during the 1988/89 dry season. However, testing during a full cropping year is most ideal.

Planning

Planning is an essential and critical stage in irrigation systems operation and management. It includes how much area will be irrigated, water scheduling, allocation and distribution, etc. Plans are primarily based on the predicted amount of available water supply and the amount that will be used or needed.

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Assessment of Available Water Supply.

The probable amount of water that will be available can be estimated from the analysis of river and rainfall data. The analysis should be done for both wet and dry cropping seasons. The dry season schedule is dependent on the completion of the wet season, and thus, cannot be planned independent of the wet season. However, details of the plans for the dry season will be made within and just before the harvest of the wet season crops.

River data. Data on streamflow are valuable when determining a river's characteristics. Using these data, the following guidelines can be used:

a. Maintain the present NIA practice of monthly discharge monitoring and yearly calibration.
b. In the absence of stochastic streamflow analysis, use the NIA procedure for averaging longest record of diverted flow into the system.
c. In cases of surface pump systems, the available river flow or streamflow records will be useful. The current NIA method of averaging the longest record of streamflow is still the only acceptable way of estimating available river flow.

If funds are available, it is recommended that NIA conducts with the National Water Resources Board (NWRB), the calibration and monitoring of streams which NIA systems are diverting water for irrigation.

Rainfall data. Most NIA systems are within the vicinity of rainfall stations with 20 or more years of records. Using these data, the probability of rainfall can be determined using the incomplete gamma function analysis. The present 5-year moving average method has a lesser degree of reliability on the weekly prediction compared with the 50% probability level of the incomplete gamma function (Serquina, C.M., 1977; Labios, L.C.T., 1979). The 5-year moving average overestimates the actual rainfall (see Figures I and 6). The rainfall records at Laoag City and Surallah, South Cotabato were used as examples in this assessment. A similar probability analysis can be made for other NIA systems.

The amount of effective rainfall should likewise be determined to have a more reliable estimate of available water supply. NIA's existing procedure may be used to compute this amount.

Estimating Irrigation Water Demand.

The demand for water is determined by the amount of water used by the crops throughout the growing period, the amount that is required in land preparation and other farming activities, and the amount that is lost through evaporation, seepage and percolation. The amounts of water used further depend on the kind of crops to be grown, soil characteristics, condition of the irrigation facilities, and other biophysical and agro-climatic factors.

Crop water requirement. In determining the amount of water needed by the crop(s), the following should be taken into consideration:

a. Each crop has its own water requirement or evapotranspiration (ET) demand. Rice is a crop with a relatively well established amount of water use at every growth stage. During the wet season, rice is the major crop. The NIA procedure for estimating the crop water demand of rice is acceptable, provided other values (e.g., seepage and percolation) are adjusted to suit local conditions.
b. The water demand of upland crops is less well known compared to rice. However, there are published and established values of crop water demand for various upland crops (Final Report, TA 654, IIMI, 1986; Philippines Recommends for Water Management for Upland Crops, PCARRD).
c. Upland crops are also sensitive to moisture deficits and water' excess. Waterlogging tolerance or sensitivity will have to be taken into consideration, particularly for leguminous crops at the early vegetative stage. Relative to rice, water demand of upland crops are more exacting. However, upland crops are also sensitive to moisture deficits especially at the reproductive stage.
d. After identifying the crops to be grown, a cropping pattern can be established using the crop characteristics and available water supply. Unless alternative cropping patterns have been introduced, cropping pattern are already established in most systems. New cropping patterns (e.g., cotton, wheat, tomato, peanut, etc. as second crop to rice) are also being tested in existing systems for adaptability.
e. Crop water demands are estimated with reference to surface water evaporation.

Thus, evaporation data are also important in estimating crop water demand (see Annex 1).

Soil water demand. The demand for water of the different soil types depends on their characteristics. The amount that will be required for land soaking and other land preparation activities depends on soil texture, infiltration characteristics and other soil properties. Losses due to seepage and percolation will likewise depend on these properties. Therefore, these properties are essential in estimating the amount of water that will be required by the soil to support crop growth.

For a specific soil type, values of seepage and percolation, saturation, residual moisture, etc., have to be estimated to arrive at the soil water demand and to determine conveyance losses in earth channels or unlined canals. In most NIA systems, the above values can be approximated depending on the type of soil (see Annex 1).

In a given area or irrigation system, it is useful to identify the soil types suitable for rice and upland crops. Their relative extent and distribution will facilitate the preparation of the plan. Mapping will facilitate identification (see Cablayan and Pascual, 1988). Sources of information or data base are diversifii land class maps, survey of existing land use and fanners' survey. Relevant maps may be available in other offices like the Provincial Development Staff (PDS), Municipal Development Council (MDC), the local Department of Agriculture (DA) offices, etc. There are a number of thematic maps prepared by the Bureau of Soils and Water Management. Although very gross and mostly province-wide in scope. these can be used to estimate soil suitability for various crops. Not all NIA systems have land evaluation maps. It is recommended that all of these systems be surveyed to have the appropriate maps.

Condition of irrigation facilities. The physical condition of the irrigation system (e.g., canals and ditches, turnout structures, etc.), will have a direct bearing on the amount of water that will be required, as it determines conveyance losses and consequently, efficiency of water delivery.

Yearly inventory and seasonal maintenance reports will provide the information on the physical capability of the system. High canal capacities to accommodate large intermittent flows are recommended for areas with coarse textured soils. Moreover, lined main farm ditches in these soils will have to be provided if large intermittent flows are to be delivered (see Annex 1).

Although lining of canals is expensive, it reduces conveyance losses, the lag time of water delivery to the different sections of the system, and time and resources spent for canal maintenance. Lining of channels is particularly important if water is scarce and earth channels are unstable and have coarse textural characteristics.

Conveyance losses are also reduced if turnouts, canal intake structures (head gates of laterals) and checking structures (cross regulators) are gated. Properly located turnouts will reduce the number of extra turnouts.

NIA's procedure in computing conveyance losses is acceptable (see Annex 1). However, it is recommended that inflow-outflow method to determine conveyance loss be instituted, particularly for unlined canals. With this method, a more accurate estimate of the actual conveyance loss can be obtained.

After determining the crop, soil and conveyance losses, the demand for crop to be planted can be assessed. In case of mixed cropping in a given turnout area, approximate requirement for both crops will be estimated. Waterlogging of upland crops will have to be considered in making the estimates and in the actual releases or implementation of these guideline.

WaferAllocation, Distribution and Scheduling

Program area determination. Programming the area which will be provided with irrigation water within the cropping season, based on the analysis of available water supply and the amount required, will help determine how water will be allocated, distributed and scheduled. NIA's present parcellary mapping program is commendable. Using parcellary maps, an accurate assessment of the actual area irrigated can be obtained. Accuracy of information is vital to optimally utilize the available water supply, particularly during the dry season

In determining the program area, water supply, crop demand and soil demand have to be considered. In most systems, however, areas nearest to water sources or areas in upstream portions are programmed for irrigation, especially during the dry season.

In system with an active irrigators' association (IA), program area determination is facilitated through the participation of the IA. However, NIA plans the program area first before the IA is consulted.

In most systems, an assessment is usually made based on the previous year's program area. This practice is acceptable provided a careful consideration of the water supply and accurate assessment of the demand is made. Furthermore, alternative crops will be considered, provided the farmers are able and willing to plant this crop.

When water supply is expected to be very Limited during the dry season, areas to he planted to rice will be confined to areas with heavy textured soils and close to the source or upstream portion of canals. However, the IA and the individual farmer's capacity to pay the irrigation service fee based on payment record are sometimes considered in determining the program area

Scheduling of *water distribution and delivery.* A schedule of water distribution and delivery is planned after the program area has been determined. This schedule is based on the availability of water supply (rainfall and river diversion discharge). A schedule is drafted, using data on water demand for the programmed area. Continuous or rotational water delivery schedule is proposed, depending on the availability of water. A continuous water delivery schedule is planned at the beginning of the dry season; rotational delivery is used when water becomes limited at mid-season up to the end of the dry season.

Implementation

Implementation includes the approval of the plan prepared by the NIA and its operational application. The plan passes through a series of meetings between farmers and NIA personnel before it is approved. In the field, monitoring is an important activity.

Meetings.

The plan is presented and discussed with the NIA field personnel, the IAs and the Provincial or Municipal Agricultural Coordinating Council.

Meeting with the NIA field personnel. The operational plan is presented to the NIA field personnel for comments and suggestions before the start of a cropping season. Possible reactions of the IA to the plan are also discussed. After modifications are made, the plan is presented to the IA.

Meeting between the NIA and the IA. A meeting between the NIA and the IA is held to discuss the program area and the schedule of water delivery. The projected available water supply is presented together with the plans for the coming season. Water allocation among farmers is also discussed. The programmed as well as the unprogrammed area is finalized during the meeting.

After an agreement between the NIA and the IA on the program area is reached, the schedule is discussed. The proposed schedule is presented for comments and suggestions to the IA members. Unless a substantial change in the plan is made, a consensus is sufficient to establish the agreement between the NIA and the IA; if not, a compromise schedule is drafted.

Presentation to the Provincial or Municipal Agricultural Coordinating Council. The schedule agreed upon by the NIA and the IA is then presented to the Provincial or Municipal Agricultural Coordinating Council. The council is composed of representatives from agencies concerned with agricultural production id the province or municipality like the NIA, the Philippine Crop Insurance Corporation (PCIC), the National Food Authority (NFA), the provincial and/ or municipal Department of Agriculture (DA), etc. The meeting is important to inform other government support agencies about the schedule of fanning activities in the area. Problems related to other support services such as availability of loans, crop insurance, seeds, fertilizers and other inputs are discussed.

Field Operations and Monitoring

The agreed upon schedule will have to be followed by the farmers and enforced by NIA. Any changes or deviations from this scheduk will have to be jointly acted upon by NIA and the IA.

Implementation of the schedule. The release or delivery of irrigation water will be in accordance with the agreed upon schedule and amounts. Adequacy of water supply will be quantitatively assessed. In most systems, NIA field personnel can estimate water adequacy by observing water elevation in the canals or intake structures. Although practical, these estimates should be calibrated every season by actual measurements to assure reliable estimates. Changes in the canal bed due to siltation makes these estimates of water elevations erroneous. If the agreed upon schedule is properly observed by the farmers and effectively enforced by NIA, conflicts and water distribution problems will be minimized.

Monitoring. Monitoring by the NIA field personnel is done to provide adequate irrigation water to the crops. Any extraneous record keeping activities by NIA will only result to fabricated records. Status of farming activities, flows or discharges at critical points and amount of rainfall are the key variables to be monitored. Farming activities should be noted on a weekly basis so as to provide enough data to base decisions on which sections of the system will need water. Flows on the critical points in the system, should likewise be used for making decisions and not for record keeping only.

Data or information should be considered important for making decisions pertaining to the management or operation of the system. Monitoring forms should be kept to a minimum, reflecting only those useful to the irrigation manager and his field staff. This system of monitoring is being piloted in several irrigation systems under the IMIS program.

A regular meeting between the IA and the NIA field staff during the cropping season is an effective means of monitoring the operations of the system. The meeting is expected to provide the feedback mechanism to make the schedule realistic and the opportunity to revise the schedule and settle conflicts in water distribution.

Evaluation

The evaluation mechanism should provide an objective assessment of the system's performance based on what had been planned. Evaluation of the actual accomplishments against what had been targeted will indicate how the system performed. Moreover, the assessment will provide information or explanation on why the system performed better or poorer than in previous years.

***Planned target* versus *actual accomplishments*.** The physical performance of a system can be assessed based on the area irrigated, area benefitted, equity of water distribution, and crop yield. Water distribution indicators will reflect the different demands of areas growing rice and non-rice, including areas with mixed cropping. Equity rather than equality is aimed for in systems with diversified crops.

The different indicators will be aggregated from the data or information monitored during the previous dry season. At this stage, the data on water flows will be utilized to determine shortfalls such that preventive measures or actions can be planned and instituted in the next dry season.

***Process* evaluation.** While a comparison between the planned targets and the actual accomplishments provides indications of the performance of a system, it does not indicate why the system performed as such. This will be provided by process evaluation. Analysis of the causes of a system's success or failure will highlight the process or activities that led to the accomplishment.

An example of an indicator of improved performance of a system is the increased area irrigated or a third crop. An analysis of the factors that might have led to this accomplishment may serve as a guide in the coming seasons when similar conditions will be present.

Implementation of the schedule is another instance where shortfalls usually occur. Farmers and NIA field personnel's culpability will have to be assessed. Improvement of procedures to make farmers more responsive and to adhere to schedules should be looked into. Group pressure or sanction through the IA is recommended with NIA's concurrence. Whatever actions to be taken to prevent shortfalls and repeat excellent performance should be acceptable to the farmers and NIA field staff. These will then be instituted in the next season and likewise be evaluated to minimize shortfalls and increase excellent performance in the different activities.

IA-NIA meetings will have to be more functional to actually meet farmers' needs.

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Annex 1

Irrigation Management Procedures Under the Laoag- Vintar River Irrigation System

The Laoag-Vintar River Irrigation System (LVRIS) is a run-of-the-river type national irrigation system with a command area of 2,377 hectares in the province of Ilocos Norte. During the dry season, only 1,243 hectares or about 52% of the total command area is imgated with about one-half planted to non-rice crops, such as garlic, corn, tomato, mungbean, peanut, watermelon and other vegetable crops. The system consists of four water-masters divisions. The main canal of about 27.5 km draws water from Vintar River and branches out to seven laterals and five sub-laterals.

Assessment of Available Water Supply

The probable amount of water that will be available has been estimated from river discharge and rainfall data. Data on river discharge at the LVRIS damsite from 1980-87 were summarized on a monthly basis. The river flow is maximum in August with a mean of 25,000 Ips and minimum in April at 1,779 Ips (Table 1).

Rainfall data from 1965 to 1987 were summarized into weekly total rainfall. The incomplete gamma distribution function was used to analyze the weekly data. The 50% probable rainfall was compared with the mean rainfall (Figure 1). The figure shows that the probability of the mean rainfall is less than 50%. Higher weekly amounts of rainfall have lower probabilities.

Estimation of Water Demand

The irrigation water requirement can be estimated from crop and soil demand, and the irriga-

Table 1. Average monthly river discharge (Ips) of Vintar River at LVRIS Dam, 1980-1987.

Month	1980	1981	1982	1983	1984	1985	1986	1987	Mean
Jan		12670	9690	11452	3164	3240	3538	4770	6932
Feb		2879	7514	7500	1645	2440	2957	1843	3825
Mar		2810	3200	2610	1710	1622	2006	1570	2218
Apr	2270	2350	2550	1067	1675	1810	1460	1050	1779
May	2100	5540	5370	880	5113	1438	1520	820	2848
Jun	9130	15070	8830	1205	10800	46070	1520	5110	12217
Jul	19000	16600	24870	5645	10000	5350	5858	6000	11665
Aug	19000	16600	33840	26258	53290	18097	8153		25034
Sep	21330	16600	26900	17667	14400	8500	4500	54000	20487
Oct	21000	18880	23480	8067	11110	7806	5200		13649
Nov	21000	15430	25600	3980	6100	5000	5890		11857
Dec	17670	13000	12740	3990	3460	4265	12120		9606
Mean	14722	11536	15382	7527	10206	8803	4560	9395	6427

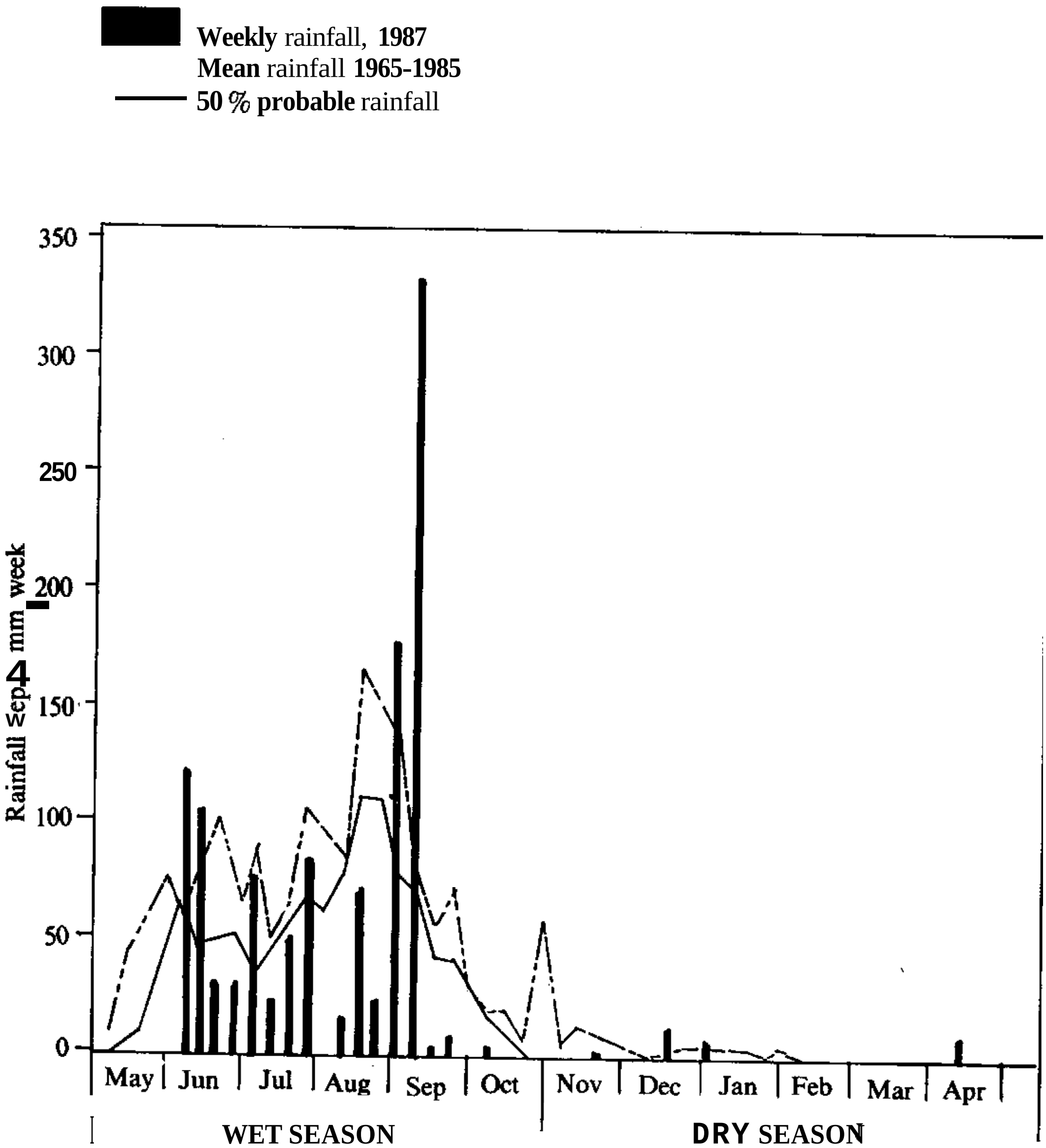

Figure 1. **Mean** rainfall, **1965-1985, 50 % probable rainfall computed using incomplete gamma distribution and** weekly rainfall, **1987.**

tion efficiency and canal capacities of the system. For lowland rice, seepage and percolation has a mean value of 4 mm/day for the entire system. Rice evapotranspiration (ET) was 5 mm/day during the wet season and 6 mm/day during the dry season. For the wet season, the soil saturation requirement was estimated at 91 mm, to be supplied in the first week of irrigation. For the dry season, the land soaking requirement was assumed to be zero, since the soil is still at saturation after the harvest of the wet season crop.

For diversified crops, water requirements were computed using the crop coefficients (KC»s) gathered from available data. KC is the ratio of the actual FT to pan evaporation. The diversified crops grown in LVRIS are garlic, tomato, watermelon, mungbean and vegetables. For these crops, the maximum ET is at about 40 to 90 days after planting (Table 2). Other characteristics of these crops are also shown in Table 2.

Table 2. Characteristics of irrigated non-rice crops commonly grown at LVRIS.

Characteristic	Crop			
	Garlic	Watermelon	Tomato/Veg.	Mungbean
Growing Period	110	105	95	70
initial stage	0-20 DAT	0-20 DAT	0-20 DAT	0-10 DAT
crop development	21-45 DAT	21-55 DAT	21-50 DAT	16-40 DAT
mid-season	46-90 DAT	56-70 DAT	51-80 DAT	41-65 DAT
late season	91-110 DAT	71-105 DAT	81-95 DAT	66-70 DAT
Planting Dates	Nov - Dec	October	Dec - Jan	Feb - Mar
Rooting Depth (cm)	30-60	45-60	30-60	45-60
Crop Coefficient(Kc) DAT's				
0 - 10	0.15	0.20	0.28	0.30
10 - 20	0.22	0.24	0.28	0.42
20 - 30	0.35	0.48	0.50	0.82
30 - 40	0.55	0.72	0.73	1.00
40 - 50	0.66	0.95	1.01	1.00
50 - 60	0.84	0.95	1.05	1.00
60 - 70	0.93	0.95	1.05	0.90
70 - 80	0.93	0.95	1.05	0.72
80 - 90	0.87	0.85	0.80	0.65
90 - 100	0.72	0.65	0.44	0.55
100 - 110	0.68	0.50	0.30	0.40
Water Use/season,mm	360-400	400-600	460	210
Irrigation Method	Basin Flooding	Basin Flooding	Furrow Irrigation	Basin Flooding
Moisture Conservation practice	Mulching	Mulching		
Irrigation Frequency				
initial stage	Monthly	Monthly	Monthly	Monthly
crop development	Monthly	Monthly	Monthly	Monthly
mid-season	1-2 weeks	1-2 weeks	1-2 weeks	Monthly
late season	none	none	none	none

DAT - Days after transplanting/planting

Table 3. Conveyance losses and canal capacities. LVRIS, crop year 1987/88.

Station	Area served (ha)	Flow (lps) Maximum	Mean Dry Season	Mean Wet Season	Distribution Efficiency (%) Dry Season	Distribution Efficiency (%) Wet Season
Main Canal Headgate	2377	6088	21 19	3897	61	71
Lateral A	82	617	196	297	67	72
Lateral B	64				83	86
Lateral E	25	70	30	36	65	66
Lateral F	653	1679	644	784	67	70
Lateral G	87	612	93	137	68	71
Lateral G-l	87	624	121	121	55	83
Lateral H	381	725	243	251	55	83

Canal capacities and irrigation efficiencies by season per lateral were summarized from previous records of the system (Table 3). The maximum capacity of the main canal is 6,088 lps with average discharges of 2,897 lps and 2,119 lps during the wet and dry seasons, respectively. Data for different sections of the main canal were also summarized but was not shown in the table. These data were used in the development of the proposed cropping schedule for the system.

Estimation of Irrigable Area and Cropping Schedule

From the above data, it was computed that the system could serve the whole irrigable area of 2,377 hectares for wet season lowland rice planting. The system could also irrigate 843 hectares of lowland rice and 834 hectares of diversified crops during the dry season. Based on canal capacities and available flow, the wet season operation should start on the first week of June. 'This is the usual start of system operation in previous years. The entire system could he land soaked for one month. Assuming rice with 120 days maturity is to be transplanted, transplanting could start by the first week of July and the area could be totally planted by the end of July. The wet season rice crop could be harvested by the middle of November (Figure 2).

Dry season rice cropped areas were assigned to areas already being programmed for this purpose in previous years. These areas are heavy textured and not suitable for diversified crops. Land preparation for these areas could be started by early November and rice transplanting could start in late November. These crops would be harvested by March (Figure 2).

Diversified cropped areas could be planted to garlic, tomato, vegetables and watermelon in November and planted to a third crop of mungbean in late February (Figure 3). This is already practiced in these areas. The second crop of diversified crops could be harvested by February in time for planting of a third crop of mungbean. The mungbean crop could be harvested by early May.

Computation of Irrigafion Diversion Reguiremenf

The irrigation diversion requirement (IDR) of the system was computed based on the proposed cropping schedule. This was done simultaneously with the computation of the progress of farming activities to ensure that canal capacities and available flow from the river are not exceeded. Also, IDR was computed separately for each lateral/section of the system to ensure that every structure in the system could handle the computed flows. However, only the whole system summary is presented in this report.

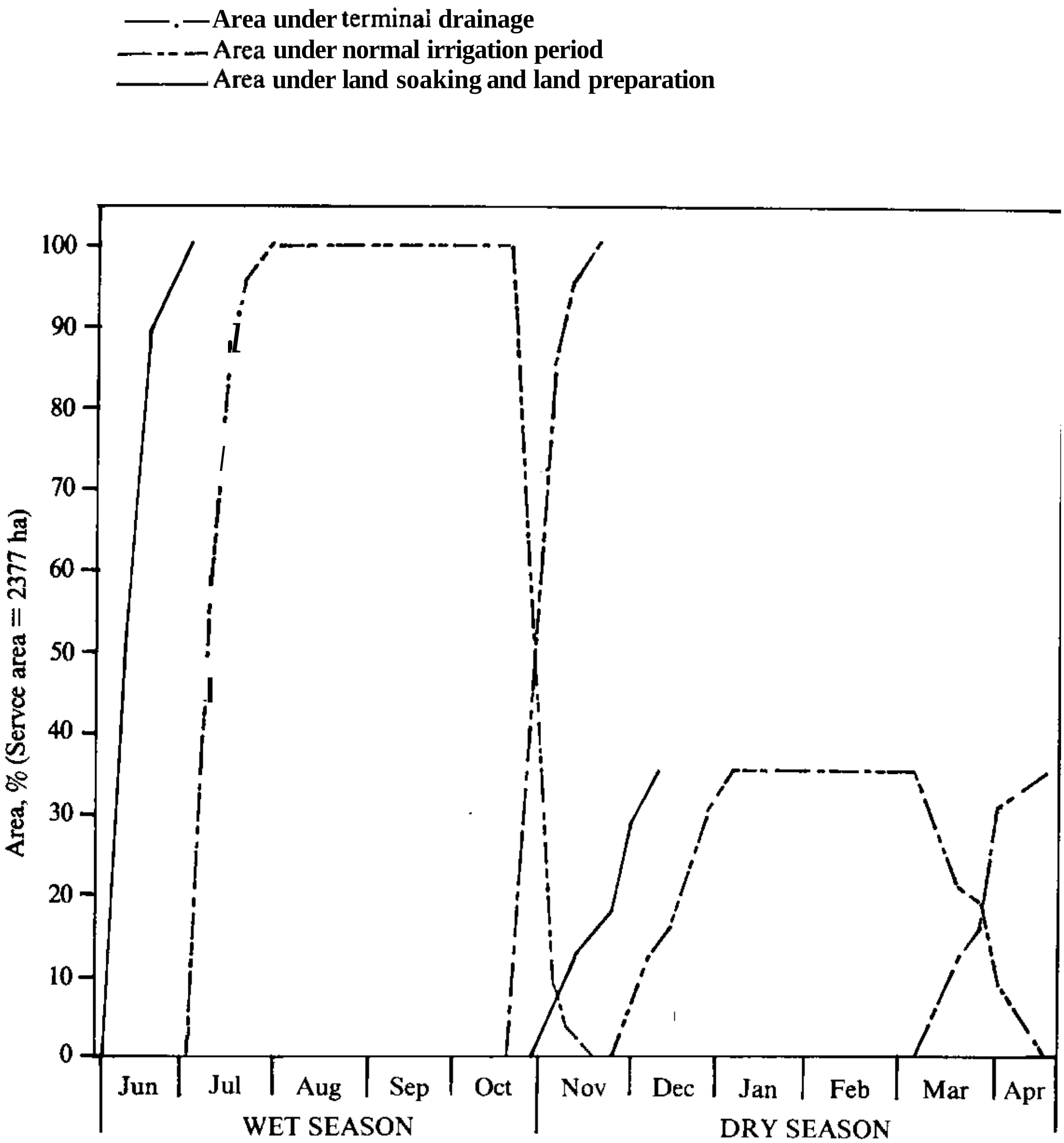

Figure 2. **Proposed weekly progress of farming activities, rice only, Laoag-Vintar River Irrigation System (Based on data for 1984-1988 and canal flow capacities).**

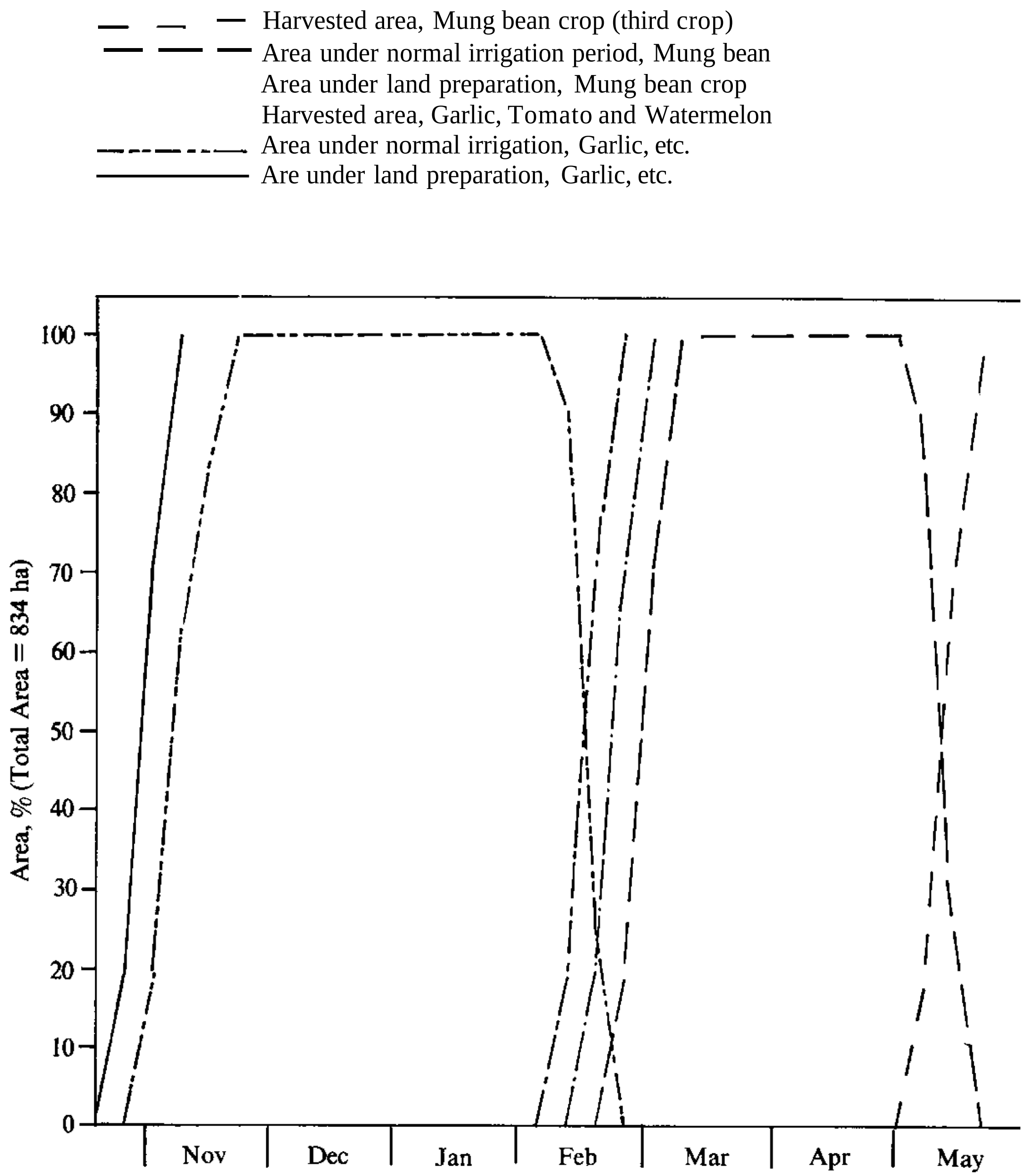

Figure 3. Proposed weekly progress of farming activities, diversified crop areas, Laoag-Vintar Irrigation System, (Based on data on cropped areas for 1984 to 1988 and Canal flow capacities)

Assuming zero rainfall, the system will have maximum IDR on the second week of operation. The irrigation will be about 30% of the mean river discharge for the entire wet season (Table 4 and Figure 4). If 50% probable rainfall is assumed, the IDR would be only 15% of the mean river discharge during the wet season.

Based on rainfall probabilities, rainfall is negligible during the dry season. Based on computations, critical water supply would be experienced in late January (Table 5 and Figure 4) and the system will not be able to fully imgate the third crop of mungbean. At present, the third crop of mungbean is being irrigated only once, depending on water availability. The first and second crops. however, could be fully irrigated.

Irrigation Management Procedures Under the Allah River Irrigation Project

Data were taken from the feasibility report of ARIP for the development of a feasible cropping schedule. The dependable flow data (Table 6), were reduced into weekly values for weekly irrigation scheduling. Only 60% of the dependable flow was assumed available. The rest will be used for flushing silt and for use by the lower dam. The

Table 4. Irrigation diversion requirements (IDR) for LVRIS, wet season rice crop based on cropped areas for 1984-87, canal capacities, and mean river discharge (river flow at damsite) from 1980-1987.

Week no.	Date	Rainfall: 50% Probable	Rainfall: 5-year mean	Irrigation Diversion Requirement (Ips) assuming Rainfall = 0	Irrigation Diversion Requirement (Ips) assuming Rainfall = 50% Probable	River Discharge (lps)
23	Jun 04-10	70	59	5061	3415	12217
24	Jun 11-17	44	76	6485	4462	12079
25	Jun 18-24	35	102	5806	3899	11941
26	Jun 25-Jul 01	52	65	5249	2226	11803
27	Jul 02-08	33	89	5423	3309	11665
28	Jul 09-15	45	50	4970	2401	15007
29	Jul 16-22	58	59	4970	1631	18350
30	Jul 23-29	68	108	4970	884	21692
31	Jul 30-Aug 05	62	99	4970	1240	25034
32	Aug 06-12	76	84	4970	459	24125
33	Aug 13-19	I13	165	4970	0	23215
34	Aug 20-26	I12	152	4970	0	22306
35	Aug 27-Sep 02	78	I36	4970	328	21396
36	Sep 0349	68	76	4970	927	20487
37	Sep 10-16	43	56	4970	2404	18778
38	Sep 17-23	40	73	4970	2574	17068
39	Sep 24-30	27	30	4970	3380	15359
40	Oct 01-07	16	20	4970	4044	I3649
41	Oct 08-14	9	19	4970	4418	13291
42	Oct 15-21	2	6	4970	4880	12932
43	Oct 22-28	0	59	2868	2868	12574
44	Oct 29-Nov 04	0	5	999	999	12215
45	Nov 05-11	I	13	225	225	11294
46	Nov 12-18	0	8	0	0	10731
47	Nov 19-25	0	7	0	0	10168
48	Nov 26-Dec 02	0	I	0	0	9606
	Mean	40	62	4103	1961	15730

- IDR's are sums of individual sections of the system
- Mean Rainfall 1975-1987
- 50% probable rainfall analyzed by the incomplete gamma function analysis.

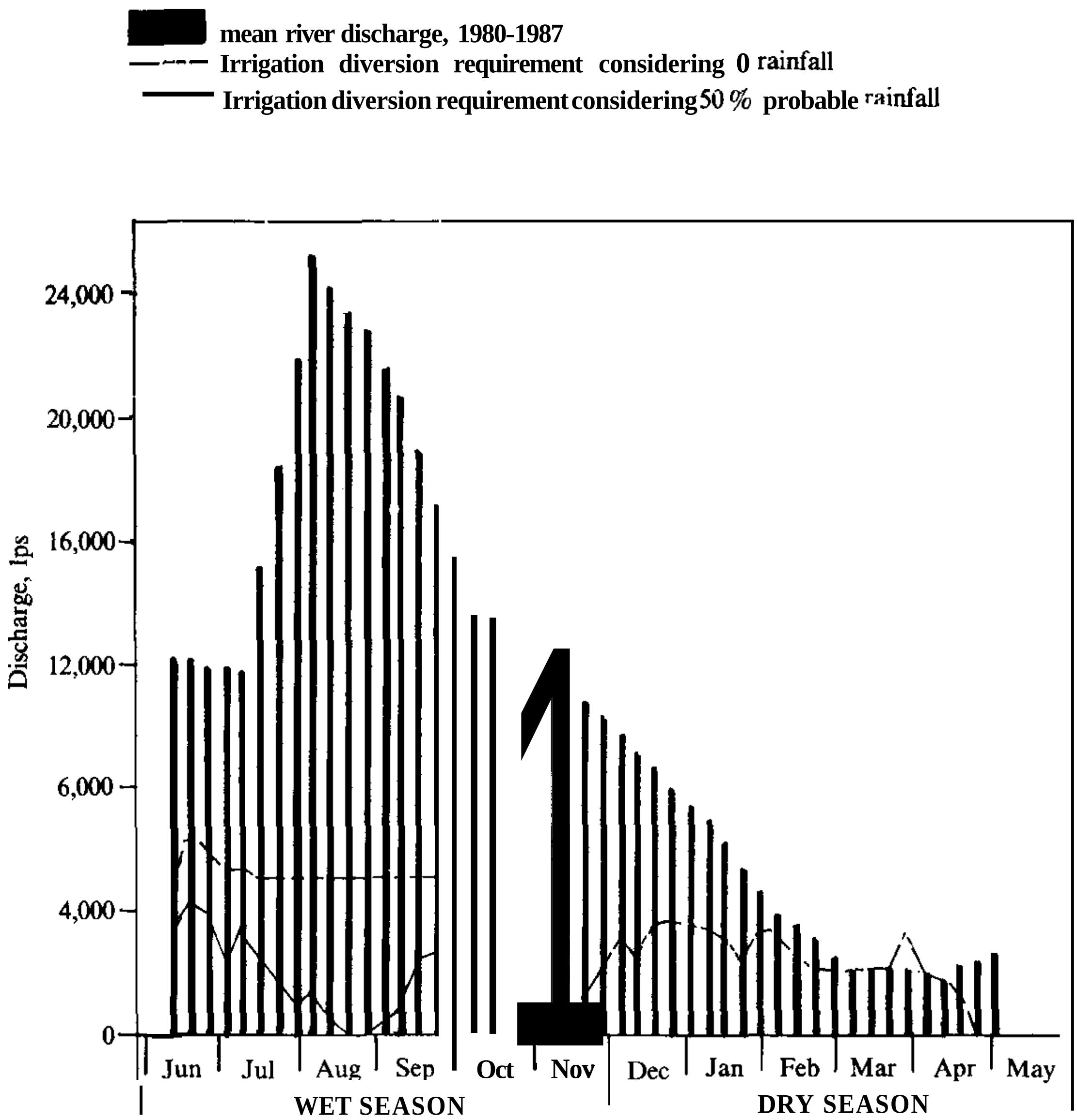

Figure 4. Irrigation diversion requirements based on proposed progress of farming activities, and mean river discharge for Vintar River, 1980 to 1987, Laoag-Vintar River Irrigation

Table 5. Irrigation Diversion Requirement (IDR) for the LVRIS, dry season crops (843 hectare - rice and 834 hectare -other crops), and mean river discharge from 1980-1987.

Week No.	Date	Irrigation Diversion Requirement (lps) Rice	O.C.	Total	River Discharge (lps)
44	Oct 22-28				
44	Oct 29-Nov 04	823	143	966	11857
45	Nov 05-11	1186	649	1835	11294
46	Nov 12-18	1052	0	1052	10731
47	Nov 19-25	1958	210	2168	10168
48	Nov 26-Dec 02	2126	904	3030	9606
49	Dec 03-09	2106	174	2280	9071
50	Dec 10-16	1832	1686	3518	8536
51	Dec 17-23	1832	1529	3361	8001
52	Dec 24-31	1832	1800	3632	7466
1	Jan 01-07	1832	1501	3333	6932
2	Jan 08-14	1832	1253	3085	6155
3	Jan 15-21	1832	418	2250	5378
4	Jan 22-28	1832	1627	3459	4601
5	Jan 29-Feb 04	1832	1514	3346	3825
6	Feb 05-11	1832	501	2333	3423
7	Feb 11-18	1832	304	2136	3021
8	Feb 19-25	1832	331	2163	2619
9	Feb 26-Mar 04	1832	113	1945	2218
10	Mar 05-11	1832	380	2212	2130
11	Mar 12-18	1493	656	2149	2042
12	Mar 19-25	1144	2242	3386	1954
13	Mar 26-Apr 01	994	953	1947	1866
14	Apr 02-08	533	962	1495	1779
15	Apr 09-15	192	1295	1487	2046
16	Apr 16-22		156	156	2313
17	Apr 22-28				2580
	Mean	1560	852	2349	5447

- Irrigation Diversion Requirement is the sum of all sections.
- Rainfall for dry season is 0 for all weeks.

water requirement of lowland rice based on different soil types was also considered (Table 7). The land soaking requirement was computed to be 90 mm and will be supplied during the first week of irrigation. Irrigated areas and canal capacities per lateral are summarized in Table 8.

Rainfall data from 1965 to 1985 were taken from the weather station at Norala, South Cotabato, which is within the service area. This data was summarized into weekly values, which were analyzed using the incomplete gamma distribution function. Figure 5 shows the weekly rainfall for South Cotabato. The mean rainfall has a probability of less than 50%. This means that the mean rainfall could not be expected once in two years.

The start of operation for the wet season was based on crop year 1987/88. During this season, the farmers clamored that the system should start operation in early April as water is already available and farmers are ready to start cropping. The area that could be land soaked weekly was computed based on the dependable flow and land soaking requirement, to come up with the weekly progress of farming activities (Table 9). The assumed operation was tail-first, which was already adopted by the system since it started operation in 1986. A 120-day rice variety was considered. During the wet season, the entire area of 7,300 hectares could be planted to rice. Figure 6 shows the resulting weekly progress of farming activities.

Table **6.** Smoothed dependable **flow.** ARIP Dam No. 1, (Taken from feasibility report of ARIP).

Period		Dependable flow, lps lps/sq. km.	Total A = 483 ha	60% of Dependable Flow
Jan	1-10	19	9274	5564
	11-20	26	12365	7419
	21-31	24	11495	6897
Feb	1-10	23	10868	6521
	11-20	22	10771	6463
	21-28	21	10143	6086
Mar	1-10	20	9708	5825
	11-20	18	8549	5129
	21-31	16	7680	4608
Apr	1-10	16	7487	4492
	11-20	18	8549	5129
	21-30	19	9322	5593
May	1-10	20	9757	5854
	11-20	22	10433	6260
	21-31	26	12655	7593
Jun	1-10	36	17340	10404
	11-20	42	20189	12114
	21-30	41	19658	11795
Jul	1-10	35	17050	10230
	11-20	36	17388	10433
	21-31	38	18306	10983
Aug	1-10	36	17195	10317
	11-20	28	13717	8230
	21-31	26	12461	7477
Sep	1-10	31	14876	8926
	11-20	37	11774	10665
	21-30	38	18257	10954
Oct	1-10	38	18306	10983
	11-20	37	17919	10752
	21-31	39	18982	11389
Nov	1-10	40	18789	11273
	11-20		19513	11708
	21-30	40	19513	11708
Dec	1-10	41	19658	11795
	11-20	37	17968	10781
	21-31	34	16615	9969

It was also assumed that after harvest the areas could immediately start wet season operation. Considering transplanted rice, time from land preparation lo transplanting is **4** weeks. The whole system could be planted for the wet season toward the end of July (Figure **6).** The light soil areas of the **extra** laterals would be planted last. This would result in the harvest of the wet **season rice** crop in these areas by November which is a more acceptable time for fanners to plant corn.

Table **7.** Turnout water requirement (lps/ha) of different soil textures for lowland rice crop, ARIP, (Taken from feasibility Report, ARIP).

Soil Texture	**Dry** Season	Wet Season
Clay loam	1.30	1.16
Loam	1.45	1.30
Sandy Loam	2.02	1.88

Except for the extra laterals, all areas are programmed for lowland rice planting for the dry season. The extra laterals are programmed for corn. Planting would start by early December. The crops will be ready for harvest by late March assuming 105-day variety. Computations for the extra laterals for the progress of farming activities during the dry season was patterned on the simulation procedure used in Lateral A-Extra as reported in Final Report, TA 654 PHI (IIMI, 1986).

Based on the computed progress of farming activities, the IDR was computed. This was compared with the dependable flow (Tables 10 and 11 and Figure 7). Assuming zero rainfall, the system cannot will not be able to irrigate the entire area. Assuming 50% probable rainfall, the system would only need about 60% of the available flow for the whole crop year. Canal capacities were not to be exceeded even when rainfall does occur in these computations,

Table 8. Irrigable areas, ARIP.

Canal/ Lateral	Canal Length (km)	Canal Capacity (lps)	Irrigable area (ha)
Main canal	20.13	14303	731I
Lateral A	7.98	4516	2192
Lateral A-I	7.08	1442	700
Lateral A-2	2.59	393	191
Lateral A-3	6.05	1730	840
Lateral A-3a	4.40	643	312
Lateral B	8.71	1669	810
Lateral C	7.84	1318	640
Lateral D	5.86	1374	667
Lateral E	3.50	976	474
Lateral A-Extra	4.80	391	296
Lateral B-Extra	3.65	475	360
Lateral C-Extra	3.71	486	368

Table 9. Progress of land soaking, wet season rice crop, ARIP.

Week No.		Increment area land soaked (ha)	Total area land soaked (ha)	Area covered
14	Apr 02-08		I209	MC TO's & Lateral D, C & E
15	Apr 09-15	790	1999	-do-
16	Apr 16-22	529	2528	-do-
17	Apr 23-29	422	2949	-do-
18	Apr SO-May 06	224	3173	MC TO's & Lateral B
19	May 07-13	180	3353	-do-
20	May 14-20	156	3509	-do-
21	May 21-27	448	3958	-do-
22	May 28-Jun 03	622	4580	Lateral A, Al, A2, A3 & A3a
23	Jun 04-10	761	5341	-do-
24	Jun 11-17	889	6230	-do-
25	Jun 18-24	312	6542	Lateral A-, B- & C-Extras
26	Jun 25-Jul 01	255	6797	-do-
27	Jul 02-08	255	7052	-do-
28	Jul 09-15	250	7302	- do
29	Jul 16-22			
30	Jul 23-29			

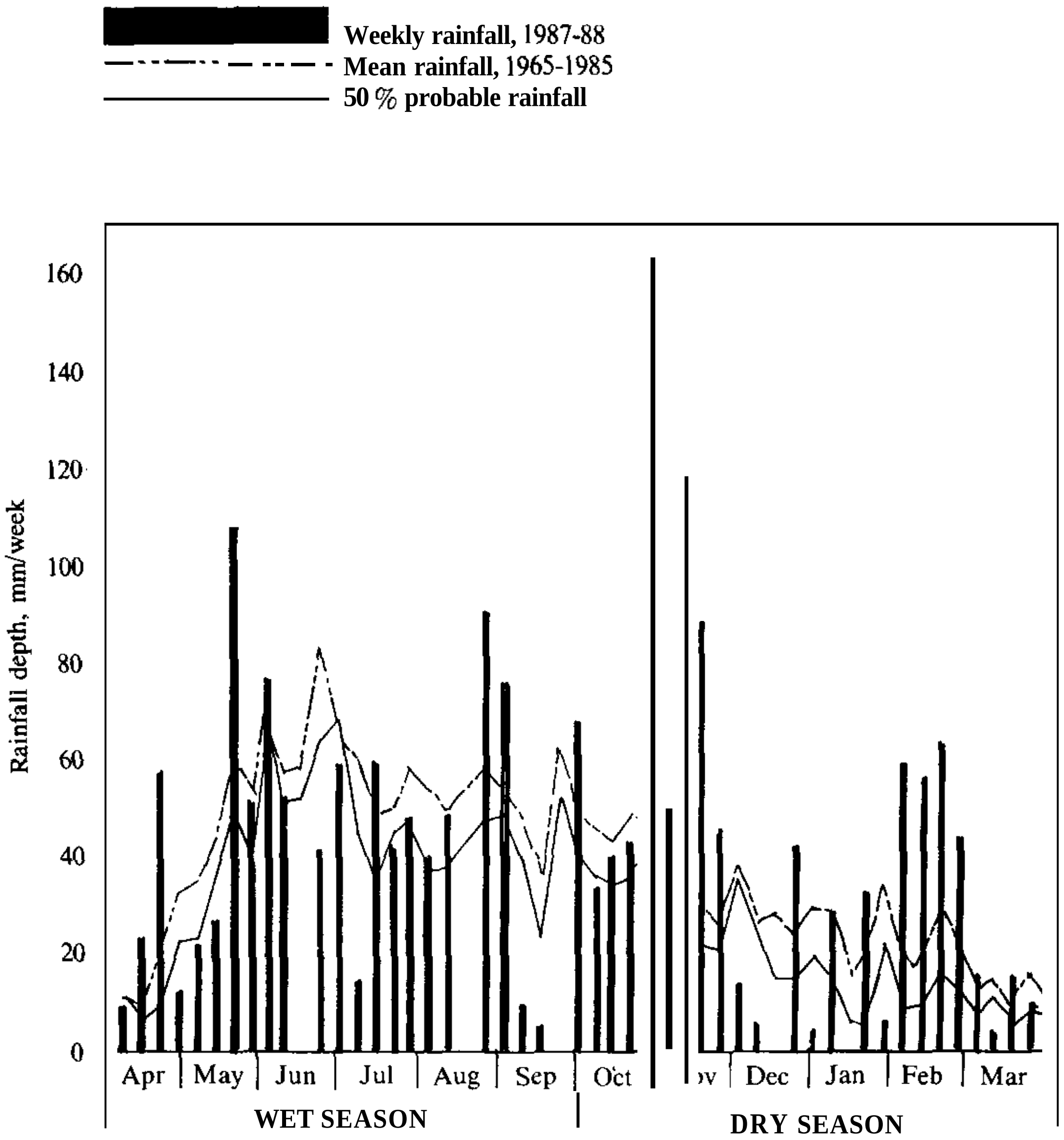

Figure **5. Mean rainfall, 1965-1985, 50 % probable rainfall computed using incomplete gamma distribution and weekly rainfall, 1987-88, South Cotabato, Philippines.**

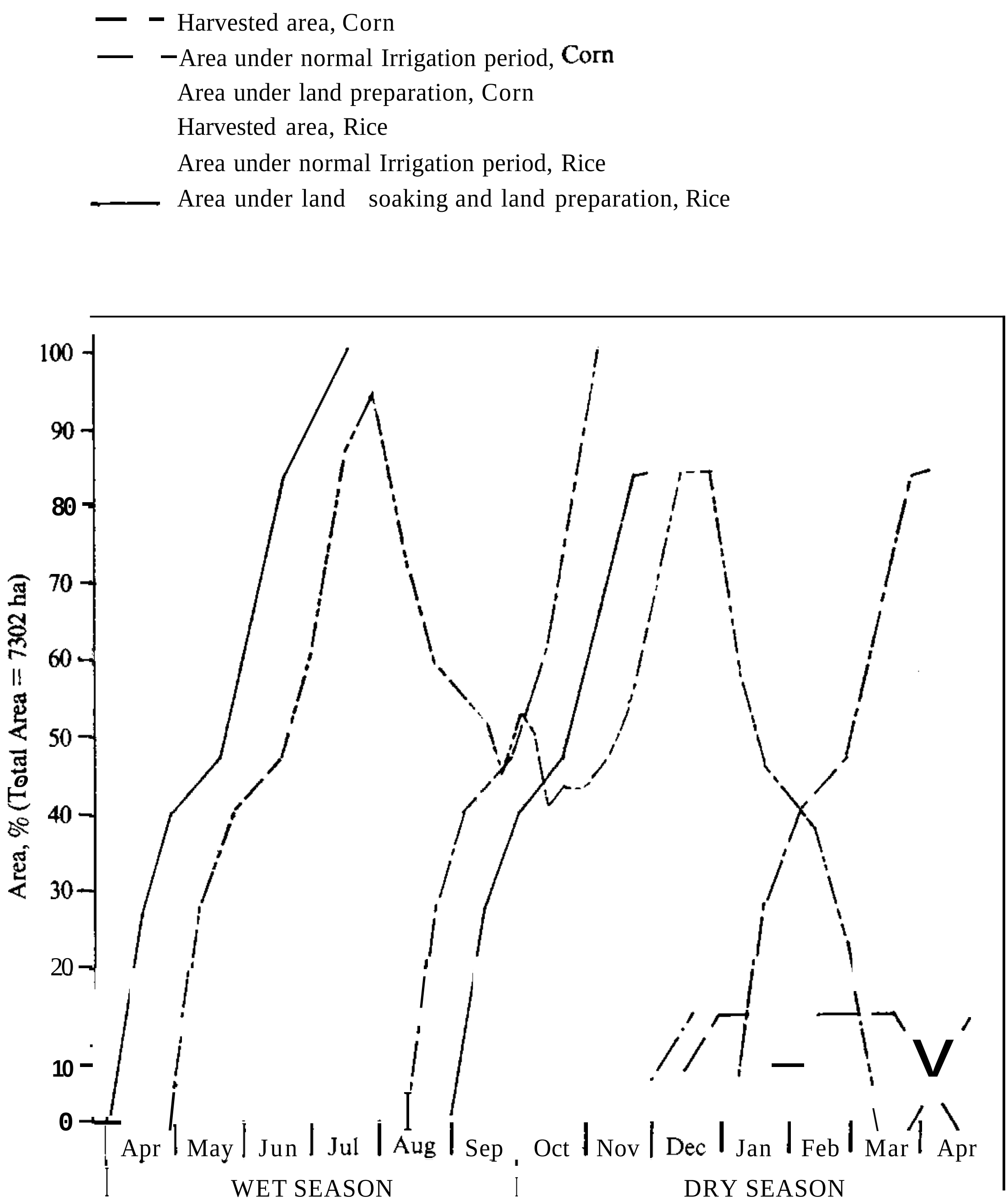

***Figure* 6.** Proposed weekly progress of farming activities, Allah River Irrigation Project, (Based on 60 % of dependable flow at Allah River).

Table 10. Dependable flow, rainfall, assumed progress of farming activities, area under land soaking and land preparation (LS/LP), area under normal irrigation period (AUNIP), area harvested (AH), irrigation diversion requirement assuming 0 rainfall (*), and assuming 50 %probable rainfall (**), wet season, ARIP.

Week no.	Date	60% of Dependable flow (lps)	Rainfall (mm)	LS/LP (ha)	AUNI (ha)	AH (ha)	Irrigation diversion requirement (lps) *	**
14	Apr 02-08	4492	11	1209			4492	4274
15	Apr 09-15	4811	5	1999			4811	4639
16	Apr 16-22	5129	9	2528			5129	4762
17	Apr 23-29	5593	22	2949			5593	4515
18	Apr 30-May 06	5854	22	3173	I209		5854	4689
19	May 07-13	6057	34	3353	1999		6057	4161
20	May 14-20	6260	49	3509	2528		6260	3434
21	May 21-27	7593	39	3958	2951		7593	5054
22	May 28-Jun 03	8998	70	4580	3177		8998	3690
23	Jun 04-10	10404	51	5341	3353		10404	5892
24	Jun 11-17	12114	52	6230	3509		12114	6768
25	Jun 18-24	11795	63	6542	3958		12197	5339
26	Jun 25-Jul 01	11012	69	6797	4580		I2796	5031
27	Jul 02-08	10230	44	7052	5341		13396	8219
28	Jul 09-15	10433	35	7302	6485		13976	9750
29	Jul 16-22	10708	45		6797		13604	8195
30	Jul 23-29	10983	48		7052		13604	7784
31	Jul 30-Aug 05	10317	37		6093		11447	7679
32	Aug 06-12	9274	38		5303		10037	6670
33	Aug 13-19	8230	43		4774	I209	9094	5738
34	Aug 20-26	7477	48		4353	1999	8341	4915
35	Aug 27-Sep 02	8201	49		4129	2528	7942	4583
36	Sep 03-09	8926	39		3949	2949	7620	5048
37	Sep 10-16	10665	24		3793	3173	7342	5862
38	Sep 17-23	10810	52		3344	3353	6542	3677
39	Sep 24-30	10954	40		2722	3509	5431	3617
40	Oct 01-07	10983	35		1706	3958	3475	2484
41	Oct 08-14	10868	34		505	4580	1187	900
42	Oct 15-21	10752	36		250	5596	588	440
43	Oct 22-28	11389	41			6740		
44	On 29-Nov 04	11331	40			7052		
45	Nov 05-11	11273	27			7302		
46	Nov 12-18	11708	22			6287		
	Mean	9261	39				8135	5097

Table 11. Dependable **flow.** rainfall, assumed area under normal irrigation (AUNI) for rice and corn areas, and irrigationdiversion requirement for rice and cornareas, and total for system assuming0 rainfall('), and assuming 50% probable rainfall **(**),** dry season, ARIP.

Week no.	Date	60% of Dependable Flow (lps)	Rainfall (mm)	AUNI (ha) Rice	AUNI (ha) Corn	Irrigation Diversion Requirement (lps) Rice	Irrigation Diversion Requirement (lps) Corn	Total *	Total **
36	Sep 03-09	8926	39			1964		1964	1177
37	Sep 10-16	10665	24			3248		3248	2468
38	Sep 17-23	10810	52			4107		4107	1942
39	Sep 24-30	10954	40	1209		4792		4792	2827
40	Oct 01-07	10983	35	1999		5156		5156	3315
41	Oct 08-14	10868	34	2528		5449		5449	3542
42	Oct 15-21	10752	36	2949		5702		5702	3631
43	Oct 22-28	11389	41	3173		6431		6431	3748
44	Oct 29-Nov 04	11331	40	3353		7443		7443	4436
45	Nov 05-11	11273	27	3509		8678		8678	6321
46	Nov 12-18	11708	22	3958		10123		10123	7878
47	Nov 19-25	11708	21	4580		10216	0	10216	8023
48	Nov 26-Dec 02	11708	36	5341		10216	1224	11440	7129
49	Dec 03-09	11795	24	6230	259	10216	1340	11556	9103
50	Dec 10-16	12737	14	6287	513	10216	1340	11556	10080
51	Dec 17-23	13679	14	6287	763	10216	1340	11556	10101
52	Dec 24-31	12867	19	5078	997	8252	0	8252	6657
1	Jan 01-07	5564	15	4288	997	6968	1340	8308	7238
2	Jan 08-14	7419	7	3759	997	6109	1340	7449	7045
3	Jan 15-21	7158	4	3338	997	5424	1340	6764	6527
4	Jan 22-28	6897	21	3114	997	5060	1340	**6400**	5304
5	Jan 29-Feb 04	6521	8	2934	991	4767	1340	6107	5729
6	Feb 05-11	6492	9	2778	997	4514	1340	5854	5441
7	Feb 12-18	6463	17	2329	997	3785	390	4175	3536
8	Feb 19-25	6086	11	1707	997	2374	1340	4114	3798
9	Feb 26-Mar 04	5955	7	946	997	1538	1340	2878	2775
10	Mar 05-11	5825	11	57	997	93	390	483	473
11	Mar 12-18	5129	5		997		1340	1340	1340
12	Mar 19-25	4869	8		738				
13	Mar 26-Apr 01	460R	7		484				
14	Apr 02-08	4492	11		234				
	Mean	8956	**21**			6054	1064	6484	5078

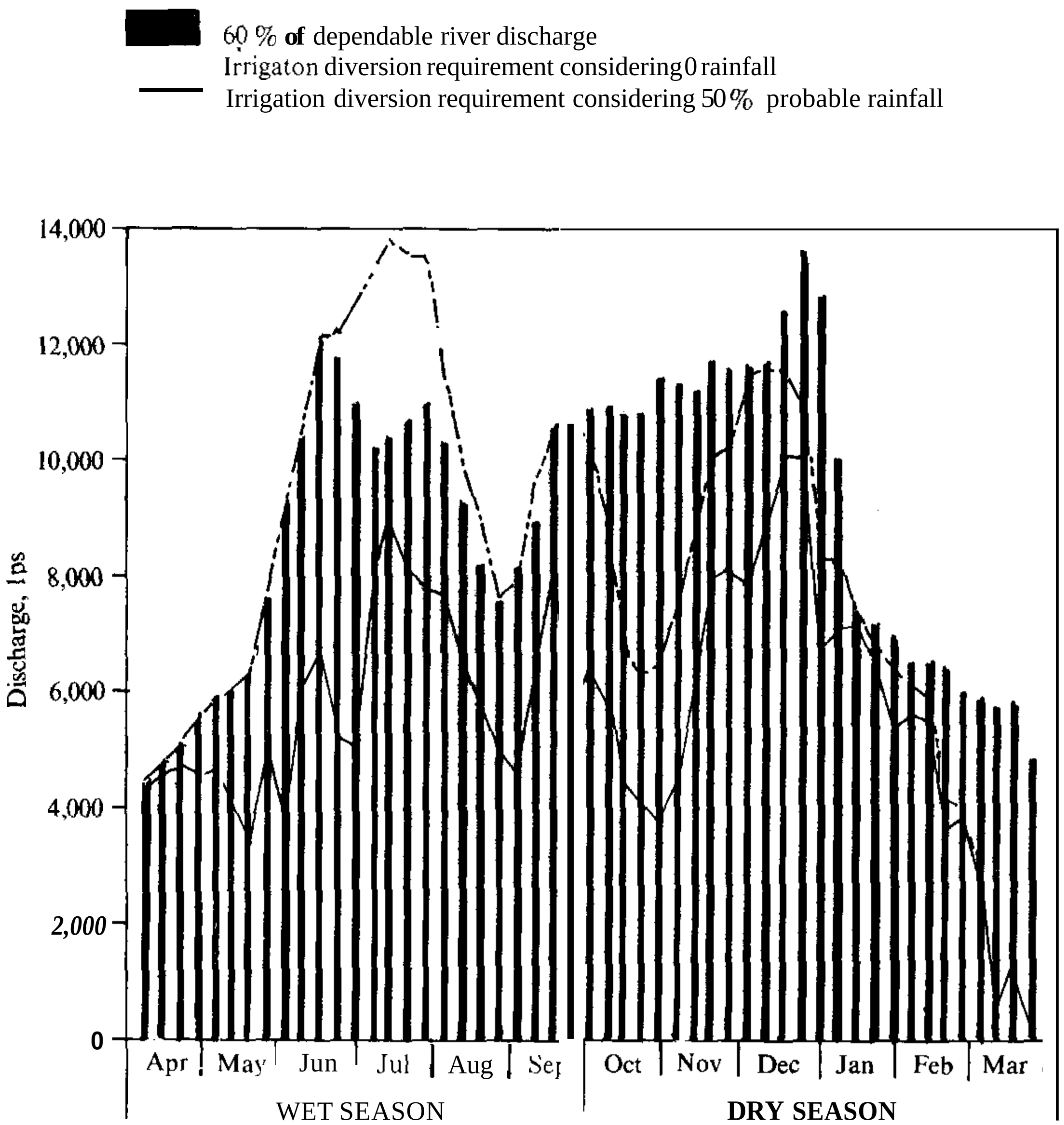

Figure 7. Irrigation diversion requirements based on proposed progress of farming activities, and 60 % dependable flow of Allah River at damsite, Allah River Irrigation Project.

Computational Procedures

Laoag-Vintar River Irrigation System.

Rice crop.

a. Basic data.

Seepage & percolation rate, (S&P)	= 4 mm/day
Residual soil moisture at start of wet season volumetric bask, (RM)	= 15%
Soil moisture at saturation, volumetric basis, (SM)	= 45%
Evapotranspiration. (ET)	
Wet season	= 5 mm/day
Dry season	= 6 mm/day
Soil bulk density	= 1.5 g/cc
Depth of soil to be saturated, (D)	= 300 mm
Farm waste, percent of requirement, (L)	= 30%

b. Computed water requirements.

Saturation requirement, (SR)
= [SM - RM]×D/100
= [45 - 15]×300/100
= 90 mm

Field land soaking requirement (assuming that land soaking requirement will be supplied in one week), (FSR)
= SR + ET + S&P
= 90/7 + 5 + 4
= 22 mm/day
= 2.53 lps/ha

Turnout land soaking requirement, (TSR)
= FSR + farm losses
= 2.53X1.3
= 3.27 lps/ha

Field normal irrigation requirement, (FIR)
= ET + S&P

Wet Season
= 5 + 4
= 9 mm/day
= 1.04 lps/ha

Dry Season
= 6 + 4
= 10 mm/day
= 1.16 lps/ha

Turnout normal irrigation requirement, (TIR)
= FIR + farm losses

Wet Season
= 1.04×1.3
= 1.35 lps/ha

Dry Season
= 1.16×1.3
= 1.5 lps/ha

c. Computation for area that can be land soaked.

For a certain canal, its maximum capacity is considered. Maximum canal capacity is divided by the canal distribution efficiency to obtain the net flow that will enter the turnouts. The result is divided by the turnout land soaking requirement to obtain the area that can be land soaked during the first week. If the total command of the canal is not land soaked during the first week, the procedure is repeated considering that the land snaked area will require an amount equivalent to the normal irrigation requirement. The procedure is repeated until all areas are land soaked.

Example: Lateral E

Area, (A)	= 25 ha
Canal capacity, (C)	= 70 Ips
Canal distribution efficiency, (E)	= 66 %
Turnout land soaking, requirement (TSR)	= 3.27 lps/ha
Turnout normal irrigation requirement, (TIR)	= 1.35 lps/ha

First Week

Available water at turnouts, (AW)	= C×E/100 = 70×66/100 = 46 lps
Area to he land soaked, (A2)	= AW / TSR = 46 / 3.21 = 14 ha

Second Week:

Area land soaked, (Al)	= 14 ha
Available water at turnouts, (AW)	= 46 Ips
Normal water requirement for land soaked area, (WRI)	= A1×TIR = 14X1.35 = 19 Ips
Available water for land snaking, (AW1)	= AW - WRI = 46 - 19 = 27 Ips
Area to he land soaked, (A2)	= AW1 / TSR = 21 / 3.21 = 8 ha

Third Week:

Area land soaked, (Al)	= 22 ha
Available water at turnouts, (AW)	= 46 Ips
Normal water requirement for land soaked area, (WR1)	= A1×TIR = 22x1.35 = 30 Ips
Available water for land soaking, (AWI)	= AW - WRI = 46 - 30 = 16 Ips
Area to he land soaked, (A2)	= AW1 / TSR = 16 / 3.27 = 5 ha

The remaining area to be land soaked on the third week is only 3 ha. Therefore the whole area can be land soaked within three weeks. The resulting progress of farming activities will be:

Week no.	Area under land soaking and land nreoaration	Area under normal irrigation	Harvested area
I	14		
2	22		
3	25		
4	19	14	
5	3	22	
6		25	
17			
18		25	
19		19	
20		3	
21		0	14
22			22
			25

The other assumptions are: the area will be transplanted on the fourth week of land preparation; rice will be harvested 105 days after transplanting; and rice will be terminally drained two weeks before harvest.

d. Computation of irrigation diversion requirement (IDR).

The complete progress of farming activities is computed based on the progress of land soaked areas. It is assumed that an area is planted 4 weeks after land soaking. A 120-day rice variety is also assumed. Based on this progress of farming activities, the IDR for each week are computed. The IDR for a particular week is equal to the IDR for land soaking multiplied by the area programmed for land soaking plus the IDR for normal irrigation multiplied by the area programmed for normal irrigation. Terminal drainage is assumed at two weeks before harvest.

Example: Lateral E

First week:

Canal distribution efficiency	= 66%
Area to be land soaked (A1)	= 14 ha
Area land soaked **(A)**	= 0 ha
Turnout land soaking requirement, (TSR)	= 3.27 lps/ha
Turnout normal irrigation requirement, (TIR)	= 1.35 lps/ha
Total land soaking water requirement, (TSWR)	= A1XTSR = 14X3.27 = **46** lps
Total normal irrigation requirement, (TNWR)	= A2XTIR = 0X1.35 = 0 lps
Lateral irrigation diversion requirement, (IDR)	= [TSWR+TNWR]/EX100 = **[46 + 0]** / 66X100 = 70 lps

Second week:

Area to he land soaked, (A1)	= 8 ha
Area land soaked, (A2)	= 14 ha

Total land soaking water requirement, (TSWR) = A1×TSR = 8×3.27 = 26 lps

Total normal irrigation requirement, (TNWR) = A2×TIR = 14×1.35 = 19 lps

Lateral irrigation diversion requirement (IDR) = [TSWR+TNWR]/ E×100 = [26 + 19] / 66×100 = 68 lps

Third week:

Area to be land soaked, (A1)	= 3 ha
Area land soaked, (A2)	= 22 ha
Total land soaking water requirement, (TSWR)	= A1×TSR = 3×3.27 = 10 lps
Total normal irrigation requirement, (TNWR)	= A2×TIR = 22×1.35 = 30 lps
Lateral irrigation diversion requirement, (IDR)	= [TSWR+TNWR]/ E×100 = [10 + 30] / 66×100 = 61 lps

Fourth week, etc.

Area to be land soaked, (A1)	= 0 ha
Area land soaked, (A2)	= 25 ha
Total land soaking water requirement, (TSWR)	= A1×TSR = 0×3.27 = 0 lps
Total normal irrigation requirement, (TNWR)	= A2×TIR = 25×1.35 = 34 lps
Lateral irrigation diversion requirement, (IDR)	= [TSWR+TNWR]/E×100 = [0 + 34]/66×100 = 52 lps

Diversified crops.

a. Basic data.

Field capacity, volumetric basis	= 40%
Soil Moisture at which irrigation is needed, volumetric basis (based on on-farm irrigation study)	= 27%

b. Irrigation requirement computation.
At planting, it is assumed that the field is at field capacity. A soil moisture balance is then computed daily. Soil moisture deple-

tion is equal to ET multiplied by the crop coefficient based on crop growth stage. When the soil moisture is depleted to 27%, irrigation is applied to bring back soil moisture content to field capacity. The same farm losses as in rice irrigation were considered since the same method of irrigation will be used (basin irrigation). This is done separately for each lateral. An example of this method is shown for Lateral A-Extra of ARIP (see Final Report, TA 654 PHI). Irrigation is stopped at two weeks before harvest.

Example: A 25 ha diversified cropped area (Garlic)

Planting date is on week 1.	
Potential evapotranspiration (PET)	= 6 mm/day
Field Capacity volumetric basis, (FC)	= 40%
Soil Moisture at which imgation is required, volumetric basis, (SMI)	= 21%

First week:

Crop Coefficient, (CC)	= 0.1
Starling moisture content, (SM) (field capacity)	= 40%
Effective root depth, (D)	= 100 mm
Available soil moisture for crop maintenance, (AW1)	= (SM - SMI) x D/100% = (40 - 27) × 100/100 = 13 mm
Moisture depletion, (MD)	= 7 × PET × CC = 7 × 6 × 0.1 = 4.2 mm
Available soil moisture at the end of the week, (AW2)	= AWI - MD = 13 - 4.2 = 8.8 mm

Second Week

Available moisture at the start of the week, (AW1)	= 8.8 mm
Crop coefficient, (CC)	= 0.15
Moisture depletion, (MD)	= 7 × PET × CC = 7 × 6 × 0.15 = 6.3 mm
Available soil moisture at the end of week the, (AW2)	= AWI - MD = 8.8 - 6.3 = 2.5 mm

Third Week

It is apparent that on the third week, irrigation is needed.	
From the first week the needed replenishment	= 13 - 2.5 = 10.5 mm = 1.2 lps/ha
Field distribution efficiency	= 80%
Turnout water delivery requirement	= 1.2 / 80 × 100% = 1.5 lps/ha

Lateral distribution efficiency	= 60%
Lateral water delivery requirement	= 1.5×25/60×100% = 62.5 Ips

If irrigation will be delivered in 8 hours then:

New lateral water delivery requirement	= 62.5 / 8×24 = 188 Ips

Suppose the lateral has a capacity of 200 Ips, then irrigation can be completed in one day.

After irrigation:

Soil moisture at start of week (at field capacity), (SM)	= 40%
Effective root zone depth, (D)	= 200 mm
Crop coefficient, (CC)	= 0.22
Available soil moisture, (AWI)	= (SM - SMI)×D/ 100% = (40 - 27)×200/100 = 26 mm
Moisture depletion, (MD)	= 7×PET×CC = 7×6×0.22 = 9.2 mm
Available soil moisture at the end of the week, (AW2)	= AW1 - MD = 26 - 9.2 = 16.8 mm

Fourth Week:

Available soil moisture at start of week, (AWI)	= 16.8 mm
Crop coefficient, (CC)	= 0.35
Moisture depletion, (MD)	= 7×PET×CC = 7×6×0.35 = 14.7 mm
Available soil moisture at the end of the week, (AW2)	= AW1 - MD = 16.8 - 14.1 = 2.1 mm

Fifth week

It is apparent that irrigation is needed:

Needed irrigation	= 26 - 2.1 = 23.9 mm = 2.8 lps/ha
Field distribution efficiency	= 80%
Turnout water delivery requirement	= 2.8 / 80×100% = 3.5 lps/ha
Lateral distribution efficiency	= 60%

Lateral water delivery requirement	$= 25 \times 3.5 / 60 \times 100\%$ $= 146$ lps
If irrigation will be delivered in 8 hours	
New lateral water delivery requirement	$= 146 \times 24 / 8$ $= 437$ lps
Lateral capacity	$= 200$ lps

The lateral will operate on the first day for 8 hours at 200 lps and on the second day for 10 hrs at 200 lps

After irrigation:

Soil moisture is at field capacity., (SM)	$= 40\%$
Effective rooting depth, (D)	$= 300$ mm
Crop coefficient, (CC)	$= 0.42$
Available soil moisture, (AW1)	$= (SM - SMI) \times D / 100\%$ $= (40 - 27) \times 300 / 100$ $= 39$ mm
Soil moisture depletion, (MD)	$= 7 \times PET \times CC$ $= 7 \times 6 \times 0.42$ $= 17.6$ mm
Available soil moisture at the end of the week, (AW2)	$= AW1 - MD$ $= 39 - 17.6$ $= 21.4$ mm

Sixth Week

Available soil moisture at the start of the week, (AW1)	$= 21.4$ mm
Crop coefficient, (CC)	$= 0.55$
Moisture depletion, (MD)	$= 7 \times PET \times CC$ $= 7 \times 6 \times 0.55$ $= 23.1$ mm
Available soil moisture at the end of the week, (AW2)	$= AW1 - MD$ $= 21.4 - 23.1$ $= -1.7$ mm

Seventh week:

Irrigation is needed:	
Needed irrigation	$= 39 + 1.7$ $= 40.7$ mm $= 4.7$ lps/ha
Field distribution efficiency	$= 80\%$
Turnout water delivery requirement	$= 4.7 / 80 \times 100\%$ $= 5.9$ lps/ha
Lateral distribution efficiency	$= 60\%$

Lateral water delivery requirement $= 5.9 \times 25 / 60 \times 100\%$
$= 246$ lps

The lateral will operate for 3.5 days at 200 Ips (8 hours operation to irrigate the 25 ha)

The process is continued until the whole season is completed.

The ***Allah River Irrigation Project.***

Rice.

a. Basic data

Seepage and percolation, (S&P)

- Clay loam areas = 4 mm/day
- Loam areas = 5 mm/day
- Sandy areas = 10 mm/day

Residual soil moisture at start of wet season, volumetric basis, (RM) = 15%

Soil moisture at saturation, volumetric basis, (SM) = 45%

Evapotranspiration, (ET)

- Wet Season = 4 mm/day
- Dry Season = 5 mm/day

Soil bulk density = 1.5 g/cc
Depth of soil to be saturated, (D) = 300 mm
Farm waste, percent of requirement, (L) = 25%

b. Computed water requirements

Saturation requirement, (SR) $= [SM - RM] \times D / 100$
$= [40 - 15] \times 300 / 100$
$= 90$ mm

Field land soaking requirement $= SR + ET + S\&P$
(assuming that land soaking requirement will be supplied in one week),
(FSR)

Clay loam areas $= 90 / 7 + 4 + 4$
$= 21$ mm/day
$= 2.4$ lps/ha

Loam areas $= 90 / 7 + 4 + 5$
$= 22$ mm/day
$= 2.5$ lps/ha

Sandy areas $= 90 / 7 + 4 + 10$
$= 27$ mm/day
$= 3.1$ lps/ha

Turnout land soaking requirement $= FSR + farm\ losses$

Clay loam areas	= 2.4X1.25 = 3 lps/ha
Loam areas	= 2.5x1.25 = 3.1 lps/ha
Sandy areas	= 3.1X1.25 = 3.9 lps/ha
Field normal irrigation requirement, (FIR)	= ET + S&P
Wet Season	
Clay loam areas	= 4 + 4 = 8 mm/day = 0.92 lps/ha
Loam areas	= 4 + 5 = 9 mm/day = 1.04 lps/ha
Sandy areas	= 4 + 10 = 14 mm/day = 1.6 lps/ha
Dry Season	
Clay loam areas	= 5 + 4 = 9 mm/day = 1.04 lps/ha
Loam areas	= 5 + 5 = 10 mm/day = 1.16 lps/ha
Sandy areas	= 5 + 10 = 15 mm/day = 1.7 lps/ha
Turnout normal irrigation requirement, (TIR)	= FIR + losses
Wet Season	
Clay loam areas	= 0.92X1.25 = 1.16 lps/ha
Loam areas	= 1.04x1.25 = 1.3 lps/ha
Sandy areas	= 1.6X1.25 = 2.0 lps/ha
Dry Season	

Clay loam areas	$= 1.04 \times 1.25$	
	$= 1.3$ lps/ha	
Loam areas	$= 1.16 \times 1.25$	
	$= 1.45$ lps/ha	
Sandy areas	$= 1.7 \times 1.25$	
	$= 2.13$ lps/ha	

c. Computation of area that can be land soaked.

For a certain week, the available flow from the dam **is** considered. The available flow is divided by the canal distribution efficiency to obtain the net flow that will enter the turnouts. The result is divided by the turnout land soaking requirement to obtain the area that can be land soaked during the first week. The capacity of the canal is considered to program the area that can be land soaked. If the total command of the canal **is** not land soaked during the first week, the procedure **is** repeated considering that the land soaked area will require an amount equivalent to the normal irrigation requirement. The procedure is repeated until all areas are land soaked (see example for LVRIS).

d. Computation of irrigation diversion requirement (IDR).

The complete progress of farming activities **is** computed based on the progress of land soaked areas. It is assumed that an area is planted four weeks after land soaking. **A** 120-day rice variety is also assumed. Based on the progress of farming activities the **IDR** for each week are computed. The IDR for a particular week is equal to the IDR for land soaking multiplied by the area programmed for land soaking plus the **IDR** for normal irrigation multiplied by the area programmed for normal irrigation. Terminal drainage **is** assumed at two weeks before harvest (see example for **LVRIS).**

Diversified ***crops,*** (extra laterals only)

a. Basic data.

Field capacity, volumetric basis	= 25%
Soil moisture at which irrigation is needed, volumetric basis (based on on-farm irrigation study)	= **15%**

b. Irrigation requirement computation.

At planting, it is assumed that the field is at field capacity. **A** soil moisture balance **is** then computed daily. Soil moisture depletion **is** equal to ET multiplied by the crop coefficient based on the crop growth stage. When the soil moisture is depleted to 27%, irrigation is applied to bring back soil moisture content to field capacity. The same farm losses as in rice irrigation were considered since the same method of irrigation will be used (basin irrigation). This **is** done separately for each lateral. An example of this is method is shown for Lateral A-Extra **of ARIP** (see Final Report, **TA** 654 PHI). Irrigation isstopped at two weeks before harvest (see example for **LVRIS).**

Dependable Rainfall

The incomplete-gamma distribution function **(IGDF) is** a 'hydrologic frequency analysis tool which is appropriate for analyzingdaily, weeklyor 10-day rainfall data. In irrigation planning, the IGDF produces a more reliable data than arithmetic means. Suppose that you have a five year rainfall data for a certain week. For four years the rainfall was zero; for the remaining year the rainfall was 50 mm; arithmetic mean will say that you can expect 10 mm of rainfall while IGDF will say that you can expect zero rainfall once in four years, which best describes the data.

The procedural analysis of IGDF **is** complex and requires a good background of statistics and hydrology. For the purpose of the study, a computer program has been developed to handle the analysis. Minimum instruction is needed for a computer user to be able to run the program. For the purpose of **NIA,** training Irrigation Superintendents (IS) to be able to analyze rainfall data using IGDF **is** not an easy task. It **is** proposed that the computer program for **IGDF** be given to the System Management Department (SMD) of **NIA** and for a user to be instructed on how to use it.

Each IS will be required to submit at least a 20-year record of daily or weekly rainfall. The rainfall record could be taken from weather stations of **PAGASA. SMD** would analyze the data and provide the weekly dependable rainfall to the **IS,** which will be used for irrigation planning. The data could be updated every five years using additional data gathered.

Agro-institutional Development Implementation for Crop Diversification at NIA-ARIP

Apolinario T. Mernpin [1]

Introduction

The National Irrigation Administration (NIA) is constructing an irrigation project in Southern Mindanao as part of the major thrust of the Philippine Government in agricultural development. Designated as the Allah River Irrigation Project - I (ARIP-I), it envisions the construction of two diversion dams across the Allah River to provide irrigation water to 18,812 hectares of rice and corn lands in the provinces of South Cotahato and Sultan Kudarat.

In conjunction with the construction of irrigation facilities, NIA has initiated a program of agro-institutional building among farmers who will be benefitted by the project. Such strategy will encourage farmers' involvement and active participation in a long-term system of maximizing the benefits from and extending the useful life of the project. Involving the farmers in the said project will also prepare them for eventual take-over of operation and maintenance.

Alternative schemes must also be developed to optimize the use of available irrigation water without evolving conflict among farmer clienteles.

Experiences at Pilot Testing Demonstration Farms involving farmer-cooperators proved that irrigated crop diversification scheme could be adopted. By promoting agro-institutional development activities, a wider area can be covered and consequently entice participation of more farmers.

Project Objectives

General. The program aims to organize the farmer-beneficiaries into viable, cohesive organizational units capable of operating and maintaining irrigation facilities to improve their standards of living.

Specific. The program seeks to attain the following:

a. Develop viable and self-reliant irrigators' associations as vehicles for group undertakings and as channels for assistance from the government as well as the private sectors;
b. Develop leadership and skills among members and officers of irrigators' associations to raise the overall efficiency in the operation and maintenance of irrigation facilities thereby maximizing the benefits to the users and extending the useful life of the irrigation system facilities; and
c. Prepare the farmer-irrigators in the proper administration and eventual management of the irrigation system at lateral level or as joint **NIA-IA** management of the whole irrigation system.

Experiences and Status Relative to Crop Diversification

Pilot Testing and Demonstration Scheme

Baaed on the Project Appraisal and Loan Agreement, a 150-hectare Pilot Testing and Demonstration Farm (ITDF) as well as its physical facilities was established in March 1980. As early as 1979, the original **92** identified farmer-tillers per approved Irrigation Network boundaries were organized into three farmer-irrigators group based on the three rotational areas and were finally organized into an irrigators' association and registered with the Securities and Exchange Commission (SEC) on **10** October 1982. Operation started in May 1980 in time for the first cropping season, Agricultural engineers, agronomists, agricultural economists, entomologists, social workers

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and other technicians from other support agencies and NIA worked together for nine cropping seasons from 1980 to 1984. A series of activities like seminar-workshops, formal training programs, on-the-job training, and field trips were conducted by the Project staff to acquaint and prepare the PTDF fanner-beneficiaries on irrigation operation, PTDF scheme implementation and for adoption of the planned socio-technical intervention and improvement of the agro-institutional activities in the area.

Aside from agro-institutional activities, the NIA-ARIP-ACD technical staff implemented demonstration and applied research activities on irrigated crop diversification at the one-hectare NIA-ARIP rented farm upstream of PTDF#1 area and paddy-paddy-mungbean demonstration farm at the two-hectare lowland within the PTDF area. Farmer-cooperators were also utilized to demonstrate and implement irrigated crop diversification with free irrigation service fee (ISF) as incentives.

During the PTDF#1 operation, the lower ISF charge for non-rice crops was not yet approved. Moreover, farmers were not interested to Join the demonstration activities since most farms were low-lying and near the Allah River bed. Based on the site experience, full implementation of the envisioned PTDF scheme was not warranted (reported by the Project Agro-Institutional Consultant from Economic Development Fund, 1983).

However, to assure implementation of the PTDF-needed support services, all agro-institutional agency heads, field technicians and farmer-leaders were involved as members of the established Project Agricultural Development Coordinating Council Task Force.

Also, to strengthen the ARIP-ACD technical research staff, a Memorandum of Agreement between NIA-ARIP-ACD and USM-SMARC was initiated and researches and demonstration activities were implemented through joint efforts for three cropping seasons (May 1982 to 1983).

After three and one half years of operating the PTDF#1 and testing/implementing the PTDF scheme, it was found that the site was not a representative area to pilot crop diversification due to its topography, soil characteristics, and negative attitude of the farmer-clienteles. Therefore, operation was shifted to paddy-paddy-mungbean scheme and another site for crop diversification was established (Per result of NIA-ADB Review Mission, 1984).

Pilot Testing and Demonstration Farm No. 2 (PTDF # 2)

NIA and ADB officials decided to establish another PTDF for crop diversification located at Dam I area which was identified as representative diversified cropland of the project area. Establishment of the PTDF#2 was initiated in 1984 and technical assistance was provided by ADB-IIMI. Operation commenced in mid-February 1985.

The PTDF # 2 Irrigators' Association (Mainuswagon IA). The site is located at the upstream area of Dam 1, lateral A-extra, Dajay, Surallah, South Cotabato with a designed service area of **296** hectares and 154 potential farmer-tillers.

The potential farmer-tillers were oriented and trained on all aspects and objectives of the project and was organized into **10** farmer-irrigators' groups based on the number **of** turnouts/rotational areas. In 1984, the groups were organized into one irrigators' association (IA). The IA was registered with the Securities and Exchange Commission on 6 March 1986 with 85 members covering an area of 200 hectares and was named Mainuswagon IA.

Extension services and other technical assistance in the area were provided by field technicians and subject matter specialists from various government and private agencies. Training programs, seminars, meetings and field trips were conducted (e.g., farmer classes on water management and crop protection, irrigators'group leaders training, and system management seminar-workshop). Irrigated crop diversification training of farmer-cooperators involved in demonstration work was also conducted through the joint effort of NIA-IIMI-DA: Farmer-participants. came from the various irrigators'associations of Dam 1 area.

PTDF#2 farmers went on educational field trips to Tacurong and President Quirino Area, Sultan Kudarat (about 50 km away from PTDF#2 Site) to observe irrigated crop diversification utilizing pumped irrigation water from shallow wells and rainfall. They also visited and interviewed fellow farmers who operated small sugarcane mills, sugarcane wine factory, and seed storage. Moreover, PTDF#2 IA farmer-members and some farmers from other laterals had regular educational field trips and orientation on the on-going NIA-IIMI-DA demonstration and research farms on irrigated diversified crops.

The occasion provided an opportunity **for** discussions among the participants. Irrigation techniques and other improved cultural practices were discussed by the farmer-cooperators with the NIA, IIMI. and DA-UIARS field staff.

The PTDF#2 Irrigation Operation. The PTDF#2 irrigation operation started in July 1985 in time for the on-going wet cropping season, and the first operation utilizing the newly constructed Allah River Irrigation diversion dam and appurtenant structures.

Proposed Cropping Pattern and Irrigaiion Schedule

Since the facilities of PTDF#2 were designed for irrigating corn and other non-rice crops, agro-institutional arrangements were made with the irrigators' association lo balance the expectations of farmers even before operation started. A series of farmer consultation meetings was conducted by the ARIP technical personnel with **IIMI** and DA field representatives and finally concurred by the ADB-IIMI consultants. Final agreement reached were:

Actual Cropping Pattern and Irrigation Schedule. During the wet season, the existing area of 9.63 hectares suited to rice will be provided with irrigation water and the remaining farms will be planted to non-rice crops. The area planted to non-rice crops could be irrigated whenever necessary. Moreover, farmers' request for irrigation to areas whose facilities could convey irrigation water to farms will be readily granted (topography problem). During the dry season, on the other hand, irrigation water will be enough only for non-rice crops. NIA will not be obliged to supply irrigation water to farmers who plant rice and will not be responsible for the crop's failure due to water shortage.

During the 1987/88 crop year, the PTDF#2 irrigation operation started in June for the wet season and in December for the dry season. This was the approved cropping calendar as a result of the NIA-IA consultative meeting on 22 September 1987.

The program area was 150 hectares rice during the wet season and 125 hectares non-rice crops during the dry season. NIA and IIMI endorsed the modified scheme per request of the IA officers and farmers. Farmers insisted to plant rice during the wet season in order that the area would be developed and ready **for** crop diversification during the dry season.

Water delivery during land soaking and land preparation was staggered - one week for every 2-3 rotational areas beginning at the tail section of the lateral. This scheme was adopted because of the soil characteristics, excessive soil percolation and limited lateral capacity. The scheme has been observed effective, thus increasing the irrigable area since its first operation. Construction **of** farm level facilities had also contributed to the increase in irrigated area.

During the 1988 dry season, there were more areas planted to rice than non-rice crops because of the extended water delivery during the wet season which lasted until 31 December 1987. The change in water delivery schedule was agreed upon in a meeting on 22 September 1987. Farmers at lateral B-extra petitioned to extend water delivery beyond I November 1987. Cut-off date for all extra laterals was reset to 1 January 1988. Thereafter, flushing exclusively for non-rice crops was allowed only upon request. A total of 29.21 hectares planted to corn and 2.60 hectares planted to soybeans were irrigated by flushing at the PTDF#2.

The effect of simultaneous demonstration and training on diversified crops contributed to the increase in irrigated areas planted to non-rice crops. It is, therefore, recommended that a series of seminars, training, field trips and demonstration on irrigated diversified crop farming be undertaken to encourage more farmers to adopt the technology during the dry season.

Projectwide Agro-Institutional Arrangements

Agro-institutional arrangements were made with the irrigators' associations, local officials and government and private agencies involved in the Project's development.

During the early years of the project, the Project Agricultural Development Coordinating Council was established to act **as** policy making body and boost implementation of necessary support services.

To reach, orient and train all potential farmer-clienteles, the project conducted formal and informal meetings at the sitio and barangay level. Other forms of mass communication (i.e., radio, bulletin, film showing and local newspapers) were also utilized. Potential farmer-tillers were identified (1980-82) based on the approved Project Irrigation Network and were organized into three farmer-irrigators groups based on rotational area. After the series of farmer consultation meetings the farmer-irrigators groups were organized into an Irrigators' Association.

As a result of the experience in PTDF#1, projectwide assessment, and identified potential constraints for implementation of Irrigated Crop Diversification. Projectwide Land Classification were updated by NIA-PDD and ARIP-ACD technical personnel before the start of irrigation operation. Results are being used by the ARIP personnel and irrigators' association as reference in programming and delineating areas for crop diversification.

Moreover, this cropping season 1988/89, one factor that will influence and encourage bigger diversified crop areas is the institutional arrangement made by the Project personnel with the various IA's regarding the strict implementation of rotational schedule specially during dry season. The rotational schedule will be based on the capability and limitation of the system specifically on the available irrigation water supply at the diversion dams.

Series of IAs meetings revealed that farmers, especially those located in the dual and diversified cropland, were willing to plant irrigated non-rice crops during the dry season if they are informed of the crop diversification scheme and the irrigation water supply limitation. Increasing area for crop diversification are now being observed at the area **for** crop diversification are now being observed at the PTDF#2. Moreover, support services (production technology, credit and marketing) provided during the development period by the government and private agencies contributed to the increased area.

To sustain the present activities and attain full development of the project. the proposed 5-year Agro-Institutional Development Program must be implemented with full support from the government.

ANNEX I: BENCHMARK INFORMATION, ALLAH RIVER IRRIGATION PROJECT

Per Feasibility and Appraisal (1978)

- Location: Provinces of South Cotabato and Sultan Kudarat
- Service area: 21,000 ha, (Dam 1 = 8,230 ha)
  (Dam 2 = 12,770 ha)
- Designed flood discharge of dams:
  Upstream of Dam 1 ____ 621 cms
  Upstream **of** Dam 2 ____ 823 cms
- Designed discharge:
  M.C. Headgate Dam 1 ____ 19.86 cms
  M.C. Headgate Dam 2 ____ 30.70 cms
- After Silt Ejector discharge:
  Main Canal - Dam 1 ____ **16.55 cms**
  Main Canal - Dam 2 ____ 30.70 cms
- Irrigated area within the service area: 1,100 ha.
  (Existing Communal Irrigation System)
- Canal System
  Dam 1 - Main Canal ____ 20.12 km.
  Lateral and Sub-Laterals ____ 62.85 km.
  Dam 2 - Main Canal ____ 22.28 km.
  Laterals and Sub-Laterals ____ **89.13** km.
- Number of Farm Households ____ 12,000
- Climate ____ no pronounced dry and wet season (4th type)
  Average Temperature ____ 27°C
  Average Annual Rainfall ____ 1,800 mm.
  (mostly from May to October)
  Maximum Intensity ____ 120 mm/hr
  Average Evaporation ____ 4.5 mm/day
  Outside Normal Cyclone Areas
- Geology and Soil
  — Alluvial deposits of clay, silt, sand and gravel
  — Principal soil type in the project area is sandy loam; low organic matter content and water retention capacity.
- Land Use and Productivity
  — 90% under cultivation
  — 15,000 ha - paddy (10% under double cropping utilizing irrigation water from Communal Irrigation System)
  — 6,000 ha - rainfed corn and other feedgrains
  — Average Yield

	Rainfed	Irrigated
Paddy	1.8 t/ha	2.7 t/ha
Corn	1.0 t/ha	- none -

  — Cropping intensity of 175% based on physical area of 21,000 ha.

- Agricultural Development

Proposed cropping pattern and projected yields. **Of** the total 21,000 hectares irrigable area, irrigated rice area during the wet season is expected to increase from 1,100 to 16,000 hectares. The remaining 5,000 hectares, which is located along the

Allah and Banga rivers, will be programmed for irrigated corn in view of the sandy nature of the soil. During the dry season, 4,800 hectares of rice and 6,300 hectares of corn will be provided with irrigation water and a maximum of 3,200 hectares of irrigated mungbean will be planted as third crop.

Except for the 5,000 hectares which will be planted to corn, the service area of 16,000 hectares will he divided into three irrigation blocks of about 5,300 hectares each for rotational irrigation during the dry season.

NIA has assured the supply of irrigation water on a rotational basis during the dry season in accordance with the proposed cropping pattern.

At full development, the average yield of paddy is expected to increase from 2.1 to 4.5 t/ha and corn from 1.75 to 3.0 t/ha. The average yield of mungbean is estimated at 0.8 t/ha.

Pilot demonstration scheme. To enhance the acceptability of the proposed cropping pattern on a rotational scheme, NIA will establish a pilot demonstration scheme not later than two years before the completion of the Project.

The scheme will consist of a training facility and a pilot farm of about 150 hectares located in Bambad, Isulan, Sultan Kudarat. The pilot farm will demonstrate: (i) efficient water management; (ii) proposed cropping patterns and rotational irrigation and, (iii) efficient farming techniques.

- Agricultural Support Services
  — Extension, credit and marketing facilities
  — Land Reform Programs and Farmers Organizations, (establishment of Irrigators' Association in the Project area and collaborate closely with Samahang Nayons (SNs) and participate in the proper operation and maintenance of the project).

Updated Project Benchmark data and limitation (as of June 1988)

- Location — South Cotabato and Isulan, Sultan Kudarat
- Service Area — 18,812 ha (7,311 ha in Dam #1 and 11,501 ha in Dam #2)
- Two barrage type diversion Dams 100% completed and Irrigation and related facilities is 97.51% completed and Project Overall physical completion is 92%.
- Irrigated Areas, (ha)
  Projectwide - 11,000 ha (59%)

	Dam 1	Dam2	Dam3
Wet Season	5,323.M)	5,677.00	11,000.00
Dry Season			
Rice	3,669.96	3,071.18	6,741.14
Non-Rice	29.56		

- Total Farmer-Tillers — 8,726
  Dam 1 Area — 3,487
  Dam 2 Area — 5,239
- Farmer-Tillers Association

	Dam I Area	Dam 2 Area
Farmer-Irrigators' Group	196	270
Irrigators Associations	15	26

- Pilot Testing and Demonstration Farms established
  Two sites: 1) Crop Diversification Area
  2) Rice-Rice-Mungbean Area
- Date of start of Irrigation Operation
  Dam 1 Area — July 1985
  Dam 2 Area — June 1986
- Record of Discharge Measurement/Observation
  Average Observed Discharge during Operation
  (Rased on O&M Unit Canal Discharge Observation)

Season	Dam I	Dam 2
WS	9.0 cms	9.0 cms
DS	5.0 cms	4.0 cms

Water Supply Availability at Allah River (Based on 3-year record [1981-1983], Watershed Development Section [WDS], ARIP)

Item	Dam I	Dam2	Remarks
Lowest Flow	10.56	15.52	April
Highest Flow	28.83	43.76	October/November

- Based on available irrigation water during summer at Allah River, the system could support only 40% irrigated paddy and 29% irrigated non-rice areas out of the 18,812 hectares total irrigable area.

Irrigation Management of Allah River Irrigation Project I

H.O. Bienes, E.A. Golingay and R. De Guzman[1]

Introduction

The first Allah River Irrigation Project (ARIP I) covers a design service area of 18,800 hectares which is expected to be in full operation by 1990. It is served by two dams, one upstream and the other downstream of the Allah River (Table I). It could supply irrigation water for rice during the wet season hut could supply only one-third of the area during the dry season. The dry season area may be increased through the introduction of diversified crops.

Hydrophenological studies revealed that Dam No. 1 (Upper Dam) area has more areas (Laterals A-extra, B-extra and portion of C-extra - all located along the Allah River) suitable for diversified cropping. Along this line, The International Irrigation Management Institute (IIMI) in co-operation with the Agricultural Coordinating Division (now Institutional Development Division) of the project, have concentrated their studies and demonstration at Dam No. I area.

A portion of the area is under operation/ programmed for irrigation. Compared with other systems, irrigation water can be easily conveyed and regulated due to concrete lined canals and steel-gated control points at canals and turnouts. ARIP I personnel (watermasters and ditchtenders) control water from the diversion point (dam) to turnout level, while members of the irrigators association (IA) receive water from turnout and allocate it among themselves. In addition, the IA assumes canal cleaning and minor maintenance of irrigation canals within their branch.

Irrigation cut-off period of a month or more is scheduled between dry and wet seasons to facilitate major repairs, as well as implement the planting schedule. This occurs during the months of February, March and April.

Operations (Dam I Area)

A tentative ***Irrigation System Operation and Maintenance Plan*** or ***Cropping Calendar*** for the crop year is prepared by NIA two months prior to the release of imgation water for the dry season. The irrigation system can supply irrigation water to only one-third of the service area or 6,000 hectares during the dry season. Out of the design service area of 7,311 hectares for Dam **I, 3,000** hectares is programmed for rice and the remaining areas for diversified crops, Laterals A-extra and B-extra are permanently programmed for diversified crops during the dry season. Other areas are programmed for diversified crops on a rotational basis. Schedule and cut-off of irrigation water from one zone to another in the remaining areas of the **3,655** hectares planted to diversified crops during the dry season is also included in the plan.

The plan is presented for deliberation and finalization during a joint meeting of NIA, presidents of the irrigators association (Ad Hoc committee), municipal officials, barangay captains, representative from the Department of Agriculture, and other government and private agencies involved in crop production. After the plan is finalized, the Ad Hoc committee passes a resolution **adopting the finalized cropping calendar.** NIA personnel then implement the cropping calendar.

All farmer-beneficiaries are informed through farmer classes, meetings of IAs, mass media and by distributing mimeographed copies of the approved cropping calendar. This cropping calendar is also disseminated to all barangay and municipal officials, government and private agencies involved in crop production.

Prior to the first irrigation release, the ARIS personnel see to it that canals and steel gates are functional and flashboards are properly installed.

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Seepage & Percolation (S&P)

During irrigation releases, the watermasters and gatekeepers make necessary adjustments of the steel gates and record daily water discharges and rainfall within the area. These personnel also take charge of helping farmers solve their irrigation-related problems with the help of the irrigation community organizer (ICO). The ICO is under the supervision of the IDD while the watermasters are supervised by the irrigation superintendent.

In case problems arise during the implementation of the plan, the NIA shall not alter the said plan without consulting the Ad Hoc committee composed of IA presidents. All areas **not** programmed for rice during the dry season but were planted to diversified crops will be served with irrigation water provided the concerned farmer files a written request with the NIA Office and he is willing to pay the irrigation service fee.

After planting, the watermasters and gatekeepers prepare a report on irrigated and planted areas which is submitted for hilling. Billing is served one week before harvest. Irrigation service fees are collected by the watermasters and gatekeepers within their respective areas.

Table *1*. Statistical profile of the Allah River Irrigation System.

Average Discharge	
a. Dry season	9.0 lps
h. Wet Season	22.0 lps
Agricultural Support Services	
a. Credit	Land Bank, PNB, DBP and Private Lenders
b. Input Supply	NFA and Private traders
Watershed and Environment	
a. Drainage Area	936 sq km
b. Physical Condition	Denuded
Problem (Major)	Water shortage during the dry season due to denuded drainage area

Note: The Bureau of Forest Development (BFD) is undertaking a reforestation on the drainage area as part of the NIA-ARIP Loan.

	Dam I	Dam II
Design Area	**7,311** ha	**11,501** ha
Canal Capacity	**17.88** cms	**30.70 cms**
Total Length of Lined Canal:		
Main Canal	20.11 km	**22.23** km
Lateral	62.53 km	**94**.35 km
Total Length of Farmditch	Construction of MFD/SFD-on-going	
Soil Type	Sandy loam	Sandy loam
Municipalities Covered	**4**	**3**
Number **of** Farmers	**3,520**	**5,329**
Water Requirement	**2.44** lps	**2.61** lps
Water Management Parameters:	(For wet and dry seasons)	
Saturation Capacity (Sn)	90 mm	
Evaporation (Ev)	**4** mm/day	
Evapotranspiration (Et)	**5** mm/day	
Seepage & Percolation (S&P)	16 mm/day	
Farms Waste and Distribution Losses (Fw+Dl)	**43% of** water requirement	
Conveyance Losses (Cl)	**4.29%** of available discharge	

Operation of Banga River Irrigation System

H.O. BIENES and O.A. TIBANG [1]

Introduction

Banga River Irrigation System (BARIS) is a run-of-the-river irrigation system designed and constructed to irrigate 3,360 hectares covering nine harangays within the municipalities of Banga, Norala, and Sto. Nino in the province of South Cotabato.

Due to siltation of the irrigation canals the service area of the system has been reduced to 2,110 hectares wherein only **1,600** hectares can be irrigated during the wet season and **1,300** hectares during the dry season. The current service area is divided into three watermasters' divisions. There are nine farmers' irrigators associations **(FIAs).** The nine **FIAs** were organized into a federation which was registered with the Securities and Exchange Commission. The federation helps **NIA** in the operation of the system, especially in planning the schedule of water distribution before each cropping season. It also helps in actual water distribution as well as in settling conflicts between farmers. The **FIAs** assumed the responsibility of clearing vacant canal sections with due compensation from **NIA. At** present, there are five **FIAs** maintaining a 17.695-km long canal.

Heavy siltation of the irrigation canals causes shortage of irrigation water. Only **20%** of the Banga river discharge can be diverted at the main canal intake; thus, irrigable area **is** greatly affected. The volume diverted fluctuates from 0.80 to 1.80 cubic meters per second (cms) in spite of daily desiltation of the settling basin.

Operations

Prior to each cropping, a cropping calendar on water delivery schedule is prepared by NIA. The cropping calendar is presented for deliberation and finalization during a joint meeting of IA federations, barangay officials, Department of Agriculture, lending institutions and other government and private agencies involved in crop production. This meeting is held one month before the release of irrigation water. The plan includes data on water management, irrigation releases, irrigation diversion requirement, programmed area and cut-off period. After thorough evaluation, deliberation and revision, if any, the **IA** federation passes a resolution approving the adoption of the cropping calendar. The cropping calendar **is** implemented by **NIA** personnel. Farmers in areas not programmed for rice or **for** water cut-off are encouraged to plant corn and other diversified crops. Usually two to three IA areas are scheduled for water cut-off.

Farmers are informed regarding the approved cropping calendar through meetings and by distributing mimeographed copies of the approved cropping calendar and the IA resolution to concerned individuals.

The area programmed for irrigation is divided into either two or three groups. Each group is provided with water for a specified number of days for landsoaking/ land preparation up to crop maintenance. The first group is usually one month ahead of the second group, and the second is one month ahead of the third. In case problems arise during implementation, **NIA** shall not alter the plan without first consulting the **IA** federation. Canals and turnouts of areas not programmed for irrigation are closed and all unauthorized checks along the irrigation canals are removed by the **NIA** personnel with the assistance of the **FIA** officials. Canals are closed to avoid illegal diversion of irrigation water to the excluded areas. Since this method has been implemented over the last five years, problems on irrigation water and farmer's conflicts had been solved gradually.

However, there are areas scheduled for water closure which are not suitable for other crops like corn due to the area's hydrological and topographical conditions. Since most farmers in these

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areas insist on planting rice, NIA and IA agree to provide the area with irrigation water provided the programmed rice areas have been irrigated and with the condition that farmers are willing to pay the irrigation service fee. For areas planted to non-rice crops, farmers are allowed to irrigate their crops, especially during drought as long as the water schedule for the programmed areas will not be affected and they pay their irrigation service fees. In some areas, farmers plant corn or other crops adjacent to rice paddies. These crops can be irrigated through seepage. Such areas will not he billed because fanners claim that they are not directly served with irrigation water. In this regard, NIA is not liable to pay for the damaged crop due to seepage since the area is part of the programmed area for irrigation.

Unequal distribution of irrigation water in the programmed area is also prevalent. Such situation usually occurs either when the river overflows or when the dam's equipment has broke down. Fanners are then forced to make illegal checks along the irrigation canals. During such situation, farmers located downstream are most affected. NIA and the the IA officials therefore, meet to solve the problem.

In 1988, farmers planted wider areas than what was programmed resulting in water shortage during the dry and wet seasons. This shows that crop diversification is really needed in BARIS.

In 1989, NIA plans to irrigate 1,300 hectares during the dry season and 1,700 hectares during the wet season. Training of fanners on crop diversification will continue. Training programs are expected to help maximize crop production and solve the problem of water shortage.

Table 1. Statistical profile of the Banga River Irrigation System.

Item	Characteristics
Potential Irrigable Area	3,360 ha
Canal Capacity	10.0 cms
Total Canal Length	
a. Lined	10,746 km
b. Unlined	39.229 km
Total length of Farmditch	148.65 km
Soil Type	Sandy loam
Water Requirement	3 lps/ha
Present Service Area	2,110 ha
Number of Municipalities covered	3
Number of Barangays	9
Number of Lots	450
Number of Landowners	404
Number of Farmers	1,358
Water Availability (5-year record)	
a. At the River	5,026 lps
b. At the Canal	1,202 lps
Agricultural Support Services	
a. Credit	Land Bank, PNB, DBP and Private Lenders
b. Input Supply	Land Bank & Private companies
Processing	Private millers and driers
Marketing	NFA and Private traders
Watershed and Environment	
a. Area	324 sq km
b. Physical condition	Denuded
Major Problem	Water shortage due to heavy siltation

Water Management Scheme at the Upper Talavera River Irrigation System

Arturo Guzman Arocena [1]

Description

The Upper Talavera River Irrigation System (UTRIS) is located approximately 200 km north of Manila, in the province of Nueva Ecija. UTRIS is a zone of District I of the Upper Pampanga River Integrated Irrigation System (UPRIIS). The system is a run-of-the-river type and reservoir independent. It has a service area of 5000 hectares.

Management Structure

Operation and maintenance are integrated. Operational aspects are handled by an Operations Engineer While maintenance aspects are handled by a Maintenance Engineer. Overall supervision and management is entrusted to the District Chief who is responsible to the Operations Manager.

A zone engineer supervises overall irrigation water allocation and minor maintenance work,

The system is subdivided into divisions covering 750-1000 hectares. Each subdivision is under the jurisdiction of an Assistant Water Management Technician (AWMT) who is assisted by ditchtenders.

Planning and Implementation

In UTRIS, planning entails estimating the potential availability of irrigation water and determining appropriate cropping systems to optimize the use of imgation water and rainfall. In determining appropriate cropping systems, allocation and distribution of water to the entire service area in sufficient quantity and on timely schedule are considered.

The following are considered when planning:

Flow discharges. Historical records of the average flow at the intake gate of the system, expressed in cubic meters per second (cms) or liters per second (Ips), are reviewed to determine the expected amount of available water during an operational year. These data together with rainfall and local inflows entering the system are important in planning appropriate strategies in the allocation and distribution of irrigation water to various divisions taking into account alternative cropping patterns.

Irrigation water requirement (IWR). The demand for irrigation water depends on the crop and its growth stage. For rice, 13 mm/day or 1.5 lps/ha of water is used as the IWR. IWR value one-fourth that of rice is used for secondary crops such as onions, garlic, peanut and watermelon.

Cropping system. The speed and progress of rice planting depends on the availability of water. During the wet season when water is sufficient, simultaneous planting within a division is practiced. During the dry season, however, staggered planting is necessary. Usually, the available water at the start of the dry season would permit the planting of wider areas than could be irrigated later in the season, hence a reduction in the area is required.

Farmer-clientele decision. Farmers' willingness to adhere to the plan is factor that must be considered. NIA personnel and the farmers concerned meet to discuss the plan before it is approved and implemented.

Plan Implementation

During implementation, the prepared plans and programs are the only bases in directing and controlling water allocation and distribution. The plan indicates expected duration of farming activities, areas to be irrigated on a weekly basis and target flows at all flow points.

Although factors considered in the planning are carefully studied and evaluated, deviation from

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the target occurs especially on the hydro-meteorological factors and weekly irrigated area. Because of this, an efficient system of water allocation and distribution has to be responsive to the varying field conditions.

If the actual water flows measured at the intake exceeds or fall short of the projected values, a system of rotation in water allocation and distribution is implemented. Distributing water on a rotational basis enables farmers to equally share it especially during the dry season when water shortage occurs. Rotation also offsets the build-up of water stress in farmers' field since the available supply can be diverted among sections with greater control and precision.

During the wet season, rice is the first crop considered because of sufficient water and no sophisticated water management concept is used. Instead, simultaneous irrigation is practiced.

During the dry season, water supply is limited especially during the later part of the crop growing period, hence rotational method is widely used in the system. The form of rotation depends on the severity of water shortage.

Rotation along sections of laterals is implemented when the actual water supply is less than 70-80% of the expected. Flows in a lateral is diverted to selected turnouts for a few days, then to another set further along the laterals.

The most widely practiced rotation under UTRIS especially from February to April when the expected flows fall short to about 50% is rotation along sections of the main canal. This system of allocation is carried out by diverting water to some laterals for a fixed number of days of the week and later to other laterals. The main canal is divided into three sections; the upstream, middle and downstream portions.

Delivery schedule follows a two day-period for the upper section, two days for the middle and three days for the downstream section. At the start, farmers follow the irrigation schedule, but later on, it is haphazardly followed and conflicts develop. Farmers often open their inlets on the wrong day, close check structures and/or sometimes erect temporary brush. Moreover, upstream fanners who plant secondary crops such as onions do not follow fixed irrigation schedules. If their crop needs irrigation even when it is not their turn, they steal water especially during nighttime.

With these farmers' attitude, the NIA personnel together with the chairman of the associations agree that ditchtenders will guard and patrol all the checking structures within the day. When illegal checks are found, the stop logs used will be confiscated and returned only on the scheduled turn at the farmers' means.

Operational Status

In 1988, planted area for UTRIS totalled 1,223.50 hectares, 670 hectares of which were planted to rice and 553.50 hectares to onions.

The total water supply for the entire dry season was 483,751 cms with an average water duty of 1.48 lps/ha.

Based on the average yield of the system, the upstream portion obtained the highest yield at 3.60 t/ha followed by the midstream portion at 3.15 t/ha and lowest at the downstream portion with only 2.25 t/ha.

Operation and Maintenance of the Laoag Vintar River Irrigation System and the Bonga Pump No. 2

Alfredo F. Lorenzo and Nemisio Y. Ines [1]

Introduction

The Laoag Vintar River Irrigation System (LVRIS) and the Bonga Pump No. 2 (BP#2) are two of eight irrigation systems comprising the llocos Norte Irrigation Service (INIS) (Table l). LVRIS, a diversion type irrigation system, has a service area of 2,377 hectares while BP#2, a pump gravity system, has a service area of 620 hectares (Table 2).

LVRIS can irrigate 2,177 hectares during the wet season and 1,500 hectares during the dry season with a cropping intensity of about 167%. On the other hand, BP#2 is capable of irrigating **493** hectares and 233 hectares during the wet and dry seasons, respectively. It has a cropping intensity of 143%.

Table 1. Irrigation systems comprising the llocos Norte Irrigation Service. 1988.

System	Service Area (ha)	1988 Target Irrigated Area (ha)	
		Dry Season	Wet Season
Bolo RIS	420	351	378
Cura RIS	431	244	431
Dingras RIS	1081	810	970
Laoag Vintar **RIS**	2377	1565	2377
NMC and PAS. Ext	684	441	640
Bonga Pump No. 1	298	117	150
Bonga Pump No. 2	674	215	450
Bonga Pump No. **3**	202	78	140
Total	6154	3881	5686

Table 2. System profiles, LVRIS **and** BP#2 (as of December 1986)

	LVRIS	BP#2
Municipalities covered	Vintar. Bacarra. Laoag City & Sarrat	San Nicolas & Laoag City
Source of water supply	Vintar River	Bonga River or Laoag River
Service area	2.377 ha	620 ha
Irrigaied area (wet season)	2.371 ha	
Average farm size	1,132 m^2	**1,177 m^2**
No. of farmer?	14.548	
Average Yield (t/ha)		
Wet season	3.85	4 00
Dry season	3.90	4.00
No. of Irrigation association	2	1

[1]Principal Engineer A and Agriculturist, respectively, llocos Norte Irrigation Service **(INIS). National Irrigation Administration,** Laoag, Ilocos Norte.

Table 3. Irrigation network of LVRIS.

Canals	Length (m)	Program Area (ha. 1988) Dry	Wet	Soil Texture
Main Canal				
MTO MC-I	1350	14	15	Clay loam
MC-2	842	14	15	Clay loam
MC-3	3870	168	168	Clay loam
MC-4	6628	117	117	Loam
MC-5	3210	59	85	Loam
MC-6	4237	127	330	Clay
MC-7	3503	46	192	Clay
End MC	3819	37	75	Clay
Laterals				
Lat A	5664	65	82	Clay loam
Lat B	2220	58	84	Clay loam
Lat E	1960	24	25	Loam
Lat G	4420	77	87	Sandy clay loam
MTO Lat H	1285	20	88	Loam
Lat P	8650	79	381	Loam
MTO Lat F	1950	26	30	Loam
Lat F	9138	I29	263	Loam
MTO Lat FI	1350	35	35	Loam
Lat FI	2206	90	208	Loam
Lat Fld	3900	58	117	Sandy loam

Table *4.* Irrigation network of BP#2.

Canals	Length (m)		Planted Area			Texture Soil
			Dry		Wet	
	Drv	Wet	Rice	OC		
Main Canal	6080	9500	5	23	178	Clay
Lat C	1400	1400		10	10	Loam
Lat B	4800	5555	141		130	Loam
Lat B-extra	I200	1200	12		40	Loam
Lat B-l	4200	4200		3	10	Loam
Lat A	900	3168	5	8	7	Clay
Total			I63	44	375	

Irrigation Network

LVRIS consists of four divisions, namely, Division I, 2, 3 and 4 with service areas of 658, 685, 381 and 653 hectares, respectively. The irrigation network is composed of a 27.5-km main canal, seven laterals (Lat A, B, E, F, G, GI and H), five sub-laterals (Lat Fl, Fla, Flb, Flc and Fld) and a number of closely spaced turnouts along the main canal and laterals (Table 3). The total canal length is 72.98 km.

BP#2 is composed of a 9.5-km main canal, three laterals (Lat A, B and C) and two sub-laterals (B-extra and B-1) (Table 4). Total canal length is 25.02 km. During the dry season, only 6.0 km of the main canal is served due to insufficient water supply.

Operation and Maintenance

LVRIS. Each of the four divisions of the system is directly supervised by a watermaster. Division I is at the upstream with cropping intensity of 180%, 4.2% (50 hectares) of which is devoted to diversified crops. Division 4 is at the downstream with a cropping intensity of 170%, 27.9% (310 hectares) of which is programmed for other crops. Divisions 2 and 3 have cropping intensities of 169% and 133%, respectively; 18.6% (215 hectares) of the former and 22.7% (115 hectares) of the latter are programmed for diversified crops. About 690 hectares (44% of the total irrigated area) were devoted to irrigated non-rice crops during the 1985186 dry season.

The watermaster, in consultation with the Irrigation Superintendent, supervises the scheduling and distribution of irrigation water within his division. With the assistance of ditchtenders, the watermaster oversees the proper maintenance and timely repair of irrigation canals and structures and collects irrigation fees. He settles conflicts on irrigation issues between farmers and acts as a bridge between NIA and the fanners.

Each division is divided into sections which is supervised by a dilchtender. A ditchtender is assigned an irrigation canal length of about 4.5 km. His responsibilities include cleaning, maintenance and repair of the irrigation canals and structures within his section. He assists the watermaster in the distribution and allocation of irrigation water and in the collection of irrigation fees.

LVRIS is characterized by several closely spaced turnouts along the main canal and laterals due to the area's undulating terrain. A farmer-team leader supervises opening and closing of the turnout. Unless instructed by the watermaster or the ditchtender, the farmer-team leader can open the turnouts everyday at minimum clearance.

When water supply is abundant, especially during the wet season, all laterals and sublaterals are continuously supplied. Rotation is done only within the division or section. However, during periods of low water supply, rotation by laterals is practiced on a weekly basis.

In either April or May, irrigation supply is cut-off to enable repair and maintenance work on the system.

Irrigation fees are paid either in cash or in kind. During the wet season, irrigation fee amounts to 100 kg paddy/ha or a cash equivalent of ₱350. During the dry season, irrigation fee for rice is 150 kg paddy/ha or a cash equivalent of ₱525. Irrigation fee for non-rice crops is 60% of the imgation fee for rice, or 90 kg paddy/ha or a cash equivalent of ₱315.

Irrigation service fee collection efficiency in LVRIS is 57.64%. LVRIS's percent viability ranges from 45-65%.

Lateral A had been turned over to an irrigators' association (IA) under NIA's stage I scheme. The IA is responsible for water allocation to areas served by the lateral. However, collection of irrigation fees is still being handled by NIA.

BP#2. BP#2 was turned-over to the Laoag-San Nicolas IA under NIA's stage III scheme. The IA is responsible for water allocation and distribution within the system and for the collection of irrigation fees. It also takes charge of cleaning, maintenance and minor repairs of the canal network. Major repairs which require the use of heavy machinery are done by NIA upon the request of the IA. A watermaster is assigned in the area to assist the association in all activities.

An irrigation community organizer (ICO) is assigned to work with the IA. A pump operator/ ditchtender is also assigned to operate the pump. Both are employees of NIA.

BP#2 has three pump units, two 200-hp pumps and one 300-hp pump. During maximum operation, the two 200-hp pumps are operated simultaneously. The two 200-hp pumps can supply water to the main canal and all laterals. The two 200-hp pumps are regularly replaced by the 300-hp pump.

Presently, only one of the two 200-hp pumps is working. This reduces the capacity of the system since the 300-hp pump cannot be operated at the same time with a 200-hp pump. Therefore, distribution of water is done on rotation by laterals.

The pumps are operated upon request and depends on the discretion of the President of the IA. One operation usually lasts for 12 hours,

Irrigation service fees can be paid either in cash or in kind. During the wet season, irrigation service fee amounts to 400 kg paddy/ha or a cash equivalent of ₱1400. During the dry season, irrigation service fee for rice areas increases to 600 kg paddy/ha or a cash equivalent of ₱2100. For areas planted to non-rice crops, the irrigation service fee is 60% that for rice or 360 kg paddy/ ha or a cash equivalent of ₱1250.

Irrigation service fee collection efficiency at BP#2 is 81.51%. BP#2 has percent viability ranging from 60-80%.

Double loading is being done by some farmers where surface pumps are used for drawing water from the irrigation canals. Moreover, the area served by BP#2 has been reduced due to the acquisition of deep well pumps by farmers.

Discussions on Presented Papers on Irrigated Crop Diversification Research

A. Synthesis and Recommendations

Mr. Charles Abemethy, Special Adviser to the IIMI Director-General and Moderator of the Session analyzed the different papers presented in terms of the goal of crop diversification. He said that there are three objectives that must be addressed: national, irrigation system or agency, and the personal objectives of the farmers. He stressed that these objectives differ with respect to crop diversification.

At the national level, four possible goals should be addressed. These are: (1) the need to use water more productively, (2) the need to increase cropping intensity during the dry season, (3) the need to reduce the rice area, and (4) the need to increase the flexibility or market responsiveness of an irrigated agricultural system. The last objective is more important than the other three because a system that is oriented entirely towards a monoculture cannot react effectively to changes in world supply of agricultural commodities.

Irrigation systems or agency objectives are concerned with the effective management of irrigation systems. They are related to the costs of running the system. Rice is the easiest crop from the viewpoint of management. But as the system proceeds towards crop diversification, the management requirement increases. This includes difficulty in water demand estimation, different planting dates, water allocation problems, rotation problems, and timing problems. These problems will ultimately increase system management costs which therefore will increase irrigation service fees.

Mr. Abemethy further stressed that one way of promoting crop diversification in these systems is the reduction of irrigation service fees as stated in the State of the Art on Water Management for Crop Diversification in Irrigated Rice-based Cropping System. Thus, a clear national policy goal on the worthiness of this program - increased management costs but with less revenue - is needed.

With regard to the personal objectives of the farmers, Mr. Abernethy mentioned that in many irrigation systems worldwide, there were failures or severe disappointment in the 1970's because of the implicit assumption that all that was needed was to provide the facilities; the farmer would then come along and make use of these facilities. This was a great mistake. Data showed that the cropping intensity during the wet season is around 74% which is enough evidence that the farmers do not necessarily take advantage of the resources just because it is there.

We do not have control over the farmers. Thus, this is the hardest policy objective that needs to be studied and considered, as it pertains to the very attitude of the farmers themselves. Studies on farmer motivation and the factors that influence his decision-making have to be conducted. There were studies conducted on this aspect but further researches is needed taking into consideration the diversity of farm household situations and the wide variety of pressures and goals that farmers may have. Possible actions to be taken to achieve these goals should be clearly defined.

Other important things to consider said Mr. Abemethy, are the experiences or policies of other countries and the economics of these possibilities, particularly the price sensitivity of the alternative crops.

B. Reactions from the National Irrigation Administration representative

Engr. Apolinario Mempin, Manager of the Institutional Development Division of the Allah River Irrigation Project, felt some perplexity with regard to the various policy objectives presented by Mr. Abernethy. However, he stressed that there was a need to assess and evaluate the opportunities and constraints to crop diversification in irrigated areas. Further research should be conducted and policies formulated to support crop diversification. With the availability of this technology, NIA can work with its clientele regarding this aspect and convince them to adopt the technology. He added that enough time was needed to persuade the farmers to practice crop diversification and to use all available strategies and approaches in terms of social, economic and technical intervention that would make the new technology advantageous to them.

C. Reaction from the Department of Agriculture (DA) representative

Mr. Renato Bayaca, Chief Develoment Project Coordinator of the Bureau of Agricultural Research (BAR) of the DA commented on the papers presented and the discussions conducted along the line of crop diversification. He noted that from DA's point of view, conflict with DA's mandate was noticed. He said that DA **is** in charge of uplifting the welfare of the farmer, thus, its focus is on the resource capability of marginal farmers. These farmers cannot afford the high cost of maintaining irrigated systems. **Unless** the various government agencies particularly NIA can work together and find ways to lower irrigation service fees, the farmers cannot be convinced to adopt the technology.

With respect to the research aspect of this technology, DA has organized BAR with a regionalized system. To find out production aspects and other things related to crop diversification at the national level, DA has groups who are working on planning and policy development and has organized an agribusiness group implementing a project component on crop diversification under the Accelerated Agricultural Production Project (AAPP). He added that if this component can bc tied-up with the IIMI project on crop diversifcation, it will be of great help in achieving success along this line.

D. Reaction from the National Economic Development Authority (NEDA) representative

Dr. Marietta Adriano, Director of the Agriculture Staff of the **NEDA** commented on the confusion created by the conflicting policies with regard to crop diversification. She said that maybe it is due to the government's intervention or non-intervention in some arras of concern. She agrees with Mr. Abernethy that an encompassing national objective is needed to increase the flexibility of improving irrigated crop production and the other three objectives mentioned should be supportive of the need to increase this flexibility.

She commented that the farmer should be given a greater option on what crops to produce and stressed that the final decision should emanate from him. The manner of providing that flexibility should open second generation problems later on wherein farmers may all move in the same direction, going into crop diversification, creating problems of supply shortages of one crop and down trend prices of other crops. Thus, crop diversification should be viewed at a regional context within the ASEAN in order to avoid supply shortages problem with neighboring countries.

The other thing needed, according to Dr. Adriano, is to integrate the economic aspects into research. **This** could possibly solve problems on the conflicting interests of the various sectors of society. As was pointed out, it is more costly to irrigate non-rice crop but NIA charges only 60% of the equivalent irrigation service fee for rice for the irrigation of non-rice crop **as** the latter utilizes less water than rice. Thus, the question arises of either NIA charging more because NIA spends more for the diversified irrigation system **or** charging the farmers less because they are actually getting less volume of water.

However. existing irrigation systems were originally designed for rice, and ***so,*** there is a need to determine the penalty cost of using these systems to irrigate non-rice crops. Inclusion of the economic aspects, therefore, **is** necessary to determine the costs to be incurred in introducing this technology to existing systems and **also** to serve **as** the basis for decision-making.

With regard the role of non-governmental organizations, the government's policy is to involve these organizations not only in research **but** in other decision-making processes of the government. **A** plan is being worked out wherein part of the official development assistance to the government from other countries will be channeled to the private sector. In this way, participation of the private sector **will** be harnessed in the country's economic development.

E. Highlights of the open forum/comments and suggestions

1. There are three questions addressed:
   a. What is really aimed at irrigated crop diversification;
   b. What are the necessary actions to be done to achieve these goals; and
   c. How do we quantify each of these actions to attain the objectives of this endeavor.

2. In addressing these questions the following issues were identified for consideration:

   a. There is a need to develop crop diversification technologies and identify the constraints which may be encountered in their adoption and possible solutions or alleviations. The efficient management of water in crop diversified irrigation systems must **be** looked into. The total production system must be considered to determine the capability of production.

   b. The appropriate irrigation fee to be charged to the farmers practicing crop diversification, especially during the dry season should be carefully assessed.

   c. **A** system by which goods would be delivered to the consumers at affordable prices **as** part of the policy objectives should be provided. Offering right prices of commodities to the farmers should also be provided.

   d. Policies regarding crop diversification in irrigation systems should consider its impact on the rainfed farmers to lessen the disparity between these two types of farmers. The rainfed resources development program of the government is aimed to help rainfed farmers and thus lessening the inequity between the rainfed and irrigated farmers.

   e. **As** most of the farmers are engaged in subsistence farming, the impact of introducing the new technology should be studied. IIMI should focus its crop diversification research with emphasis on the comparison of this technology with the traditional one **as** far **as** farmer's income is concerned. Farmers'expectation and reactions with regard to crop diversification and how the various agencies can assist them along this line are worth determining. There is a need to review past experience with rice farmers in order to avoid the same experiences when going into diversified cropping.

   f. There is also a need to study and review the marketing structure for the various commodities at the farmer's location to improve transport system and other factors.

   g. Farmers should be motivated not only to adopt the technology but also to develop it. **A** set of economic and financial incentives to the farmers to sustain their production capability with minimum budgetary requirement from the government must be provided.

   h. Government intervention with regard to the provision of facilities and infrastructures for the processing and storage of fanner's produce at the countryside is needed.

   i. The need to study the additional management requirement within the capability of the farmers and **NIA** when crop diversification is practiced is **recognized.**

j. The rehabilitation of rural banks and the removal of taxes for agricultural inputs will help farmers avail themselves of credit assistance and increase their income.

k. The government's official development assistance program will be given only to non-governmental organizations which are non-profit oriented. Nestlé, San Miguel Corporation and the like are excluded from this program.

l. The large agricultural population in developing countries should also be considered in the policy-making process in order to develop sound and effective policies in this endeavor.

Review of the *State of the Art/Abstract Bibliography* on *Water Management for Crop Diversification in Irrigated Rice-Based Cropping Systems*

The background on the publication was presented by Dr. A. Maglinao. The *State of the Art* is a regular publication series of PCARRD which is intended for the use of individual scientist, research institutions, policy and decision maker, and administrator who need to be versed in agriculture and resources research, so they can come up with research programs and policies that are relevant to the solution of urgent development problems. Complementing the situation analysis, an *Abstract Bibliography* portion presents the highlights of relevant researches that have been conducted. He added that the publication was prepared by a technical committee.

The publication analyzes the state of knowledge on rice-based cropping systems, water management in crop diversifcation and the socio-economic aspects of crop diversifcation. These topics were briefly presented by Dr. Ranola, Mr. Salandanan and Dr. Mina, respectively. Dr. Undan discussed the research gaps and direction.

Dr. Maglinao reiterated the purpose of including the presentation of the publication in the workshop. He said that it is not the purpose to revise the publication after the review but rather identify other activities related to the publication to make full use of the available information on crop diversification. He then mentioned the ***Philippines Recommends Series*** another publication line of PCARRD, which needs information like those contained in the ***State of the Art.***

The subject of drainage was raised by Mr. Abernethy. According to him, the subject has been inadequately treated in the publication and in the workshop as a whole. He stressed that with water loving plants like rice, drainage can almost be ignored, but with non-rice crop, drainage is imperative.

Dr. Undan responded that some of the information is related to drainage although not directly. He cited information on the resistance of crops to waterlogging, which is more or less related to drainage. However, he mentioned of the need to study and document farmers' water management practices in areas growing non-rice crops adjacent to rice. He cited his experiences in Central Luzon where in areas where crop: are planted alongside ricelands, fanners developed temporary drainage ditches in between to intercept water that seeps out from the rice area. He also noted that the higher water table provides extra water for the crop that leads to the less irrigation application.

Dr. Maglinao emphasized that there is very limited information as far as performance of the total system is concerned. Most of the studies have looked into smaller components of the farming system.

Dr. Undan suggested that the next phase of the work on crop diversification would be to identify and work on how the water management technologies can be incorporated into the total production technology. He cited that previous studies tended to be subject-specific; studies on water-related concerns tend to treat other cultural practices as constant, and likewise research undertaken on other cultural practices tend to consider water management as constant. He emphasized the need for an interdisciplinary approach to research.

Engr. Moya commented on Table 9 which is on the consumptive use values for some upland crops.

Engr. Mempin inquired as to whether the information in the literature can be classified according to the climatic types so that irrigation planners can use the data under particular zones. He suggested that if the data are not yet available, they should be included in future editions.

Mr. Madrigal commented that pest management was not tackled in spite of the fact that most crops identified for diversification were susceptible to pest and diseases.

Dr. Undan agreed with Mr. Madrigal's comment. However, he stressed that the authors did not come across studies relating the shift from rice to non-rice and the pest and disease occurrence in the non-rice crops due to water.

Engr. Bienes who agreed with Dr. Undan backed-up the multidisciplinary approach in research. The total production farming activities should be considered. All farming activities within the year should be considered holistically.

Dr. Maglinao commented that the multidisciplinary approach is not new. There may have been problems in the implementation hut he stressed that the thrust of IIMI Philippines is along these line.

Dr. Ranola suggested that data for the economic researches be standardized. He cited the fact that the Literature on the various aspects of crop diversification are based on specific commodities. Standardization will permit a comparison across the different commodities and across different areas. He proposed that some calculations he made on the collected data so that comparison could be made across sites.

Dr. Maglinao summarized the suggestions to improve the publication. Foremost of these was the suggestion that information from other countries be included. Second were ways and means to avoid the limitation that the paper does not consider the total system because of a dearth of information. He next cited the unfortunate omission of the definition of terms.

Dr. Maglinao noted that the group were looking for a more comprehensive analysis of the information so that they could be made useful for making recommendations like system design. Because the publication intends to present only an analysis of the research that bad been done to determine the gaps and the research direction to follow, it does not make any other recommendations. These queries can be addressed by the forthcoming publication particularly the ***Philippines Recommends for Irrigation Management for Crop Diversification.*** This publication is intended for extension workers who transfer the technologies to the farmers.

Guidelines

To start the discussion, Dr. Valera threw out the question of what the group thought to be the reason why farmers do not want to practice furrow irrigation, for example in irrigating corn. He cited IIMI's experience in Mindanao.

Dr. Caoili said that based on his observation in South Cotabato, the soil is too sandy, resulting in the difficulty of maintaining ditches. Also, even though there is high flow upstream, only a very small amount of water reaches downstream. He noted that since corn is a newly introduced crop in the area, there was not enough time for farmers to observe furrow irrigation of corn. He further stressed that in the Ilocos region, farmers irrigate corn by the furrow method.

Mr. Abernethy mentioned land levelling. He noted the paper showing useful patterns of water advances and the poor stand of field crops. He stressed that when people are accustomed to irrigating rice, land leveling is not very important and suggested that there might be a need for even fairly simple technology on this aspect.

Irrigation System Management at the Banga River Irrigation System and Allah River Irrigation Project

Engr. Bienes noted that they cannot control the decision of the farmers on which crop to plant. He said that during planning meetings of the Irrigators' Association, areas for rice and non-rice crops are delineated. What they can control is the amount of irrigation water to be given to the farmers. The farmers have the final decision on which crop to plant since they can allocate water intended for non-rice crops to irrigate rice on a much lesser area.

Dr. Miranda asked Engr. Bienes why they are using the bulldozer instead of the crane for desilting operations at BARIS. The operation takes about four hours per day. Engr. Bienes responded that the bulldozer was out of order and is beyond repair. He further stated that they cannot get a replacement since there is only one crane in the region.

Dr. Caoili commented on the large difference between the wet season and the dry season areas, which according to Engr. Bienes was caused by the denuded watershed. He asked whether NIA has a soil and water conservation program to try to arrest runoff from the watershed. Engr. Bienes responded that there was no study regarding watershed area.

Dr. Caoili stressed that rather than a study, what was really needed was a simple construction work to block runoff to alleviate the excessive fluctuation of the streamflow.

Mr. Salandanan, in response to Dr. Caoili's queries, said that the jurisdiction area of that activity is beyond the scope of the NIA and is the mandate of another agency.

Dr. Caoili was worried by this development. He said that NIA is investing ₱600 million and if there are problems, independent solutions are looked at from the perspective of different agencies. He expressed the need for an integrated approach to this concern.

Dr. Valera noted however that NIA has been thinking along the line of going beyond the damsite. He mentioned of the proposal tn create the Watershed Management Department to manage the watershed of NIA's irrigation systems. This might however create conflict with the government agency tasked with watershed management.

Dr. Miranda added that the ARIP has a watershed component.

Engr. Mnya raised a question related to the design in ARIP. He asked the difference of the design assumptions used for the laterals which are designed for diversified cropping to the design of laterals serving rice.

Engr. Bienes responded that the laterals have the same structural design but with smaller canals. He said that what was taken into consideration was the water duty for non-rice crops.

On the question of the difference in the density of facilities Engr. Bienes responded that they have the same density as for rice paddies.

On the question of viability, ARIP has a 1.7 viability index according to Engr. Bienes. Engr. Bienes further stated that the relatively high collection efficiency (72% for 1987) can be attributed to the good harvest with an average of 4.5 t/ha .

About problems of water distribution in the field, from the canal to the farm level considering that seepage and percolation values are quite large (16 mm/day), Engr. Bienes commented that is why they introduced crop diversification in the area.

Mr. Abernethy asked what is done with farmers who go against agreed cropping patterns. Engr. Bienes answered that the area for non-rice is reprogrammed in consultation with the farmer associations. What is done is to cut the supply of water so that farmers will be forced to plant other crops or else leave the area idle.

Mr. Abernethy asked what if the personal choice of the farmer is to grow rice on a reduced area. Engr. Bienes answered that if NIA gives in to the request of the farmer to plant rice on a reduced land area, they would encounter difficulties in water distribution.

Planning Workshop

Dr. Valera opened the discussion in the planning workshop. He suggested that outputs and experiences from the different studies should be the major basis. This could be in the form of what issues should further be tackled during the last dry season or improvements on the existing methodologies. To facilitate the discussion, the comnonent studies and planning for field testing were discussed separately.

A. Component Studies

The first issue taken was the socioeconomics of irrigated crop diversification. For the component at UTRIS, Dr. Marzan suggested the monitoring of prices and supply at least on a weekly basis. He theorized that since onion price has been favorable, many farmers are expected to plant onion during the 1988/89 dry season. He suggested to look at the flexibility of the market to absorb the produce after harvest.

For garlic, Ms. Caluya hypothesized that less areas will he planted at LVRIS and at BP#2, during the 1988/89 dry season. She said that the low production during the 1987/88 season caused low stocks of planting materials. She said that they will continue with their data collection.

Dr. Mina stressed that what needs to be done is not an improvement on the methodology but on the economic analysis.

On the question of T. Moya on whether there is a way to synthesize the results of the economic component study with the fiscal performance of the system, Dr. Valera mentioned that there are three aspects of the study which were related to this concern: a. relating the yield distribution within the system/what kind of yield farmers are getting: b. motivation on how farmers decide what crop to plant; and c. idea on the capacity of the farmers to pay irrigation service fees.

Dr. Marzan suggested areas of concern regarding management of systems for non-rice crops, First is the construction cost of having systems redesigned to be operated for diversified crops. Second is the potential benefits to NIA from diversified cropping in terms of larger irrigated area and more irrigation service fees. And third is the NIA incentive for promoting diversification.

Dr. Valera stressed that the management cost is an actual concern in the economic component. From the NIA's viewpoint, the extra management costs during the dry season may not he reflected in the numerical compensation that NIA staff are receiving but rather on the extra hours devoted to say, supervising rotation, or patrolling canals. He proposed that IIMI **look** at the question on whether there is more labor expended during the dry season compared to the wet season.

Mr. Abernethy proposes that IIMI study a system that is primarily rice in the dry season and another system which has a great deal of diversification.

Mr. Salandanan commented on the topic of subsidy. He proposed that a study on how much the government should provide NIA for the added cost of diversification be conducted. Dr. Martin however said that based on Engr. Bagadion's hypothesis a large scale diversification would actually increase NIA's income.

Dr. Miranda commented on the choice of crops to be studied which is onion for UTRIS and garlic for LVRIS. He suggested that IIMI consider other crops being grown not necessarily of economic importance but from the system management perspective since different crops have different requirements which the system has to respond to.

Dr. Caoili further indicated that in the case of **LVRIS,** non-rice crops being planted, besides garlic, are mungbean, tomatoes and watermelon. Even in garlic areas, some farm plots are planted to mungbean and on the whole they have 300% cropping intensity

Dr. Undan commented on the need to **look** at the social issues to be integrated with the economic issues. He cited the example of present irrigation service fees. There is a need to determine the limit for additional fees which will be acceptable to the farmers,

Dr. Martin reacted that the concern mentioned was beyond the scope of this particular project. He said that this was studied by **Drs.** Adriano and Leslie Small. He cited the conclusion that under conditions of satisfactory irrigation service, when the average yield could be attained, farmers have the ability to pay the present level of irrigation service fee and they could pay the **full** cost of operation and maintenance (O&M). And if NIA could raise the collection to close to 100% they would also recover the full cost of O&M and 10% of the capital cost.

Mr. Abernethy cited the presentation of BP#2 which has a higher collection rate despite the high service fee of **₱2000**. He said that this indicates that people will pay a much higher fee if they are satisfied with irrigation, stating that in a pump scheme, satisfaction is more or less guaranteed because of better control. He further said that the relationship of the quality of irrigation to the willingness of farmers to pay irrigation fee is worth looking into.

Dr. Martin pointed out that data from around the world indicate that farmers in systems they own are willing to pay very high amounts of irrigation fees. However, it was clarified by Mr. Ines that the amount they collect are only **for** the pump operation cost and not an amortization, and the ₱2000 irrigation **fee** rate was only for electricity which is consumed by the pumps.

Mr. Abernethy then posed the question that despite the high irrigation service fee, farmers still pay. Dr. Miranda said it is a pump system and it is the policy of NIA not to operate the system unless they get pledges of at least 90% collection. **So** if this 90% is not reached then farmers will have no water.

Engr. Moya added that in India, pump users are willing to pay twice **as** much from agency run systems because water is coming more reliably.

Mr. Guino mentioned that what is needed is the actual design cost in rehabilitating partially irrigation systems to accommodate non-rice crops. If these data become available, they could superimpose these onto the benefit-cost analysis on the viability these systems with respect to crop diversification. These are the structural costs. On the issue of management cost, he stressed that if the additional management **cost** of managing diversification would entail increases in imgation fees, these would become a disincentive for the farmers to diversify. He stressed that the current rate for non-rice crops, which is 60% that for rice, is an incentive to farmers to plant non-rice crops. If this rate is increased, this would be another problem because farmers will have to be convinced again on this new rate.

Engr. Bienes cited the result of the study of Dr. L. Gonzales that Mindanao has no comparative advantage in non-rice crop production. If this is the case they will program the available water for rice crop production and let the rainfed areas plant non-rice crop instead. He stressed that it is hard to convince farmer to plant non-rice crops. He cited the need to determine if allocating water for non-rice would give more benefit than allocating the water to rice alone.

On the aspect of irrigation methods for non-rice crops, Mr. Abernethy suggested that the **best** methodology is the use of simulation modeling. It is the most efficient way of determining whether the irrigation systems have sufficient facilities for controlling water so that water can be delivered when it is needed. He further stressed that this technique is available at IIMI.

Dr. Valera agreed. He said that simulation models are a more manageable tool for verifying possibilities in irrigation systems. He added that these might be an interesting dissertation for a graduate student.

On the question on whether IIMI is interested in both the farm level and the systems level studies, Dr. Valera said that the IIMI-IRRI Project will not touch on the farm level aspects. However, in the ADB Project, one of the objectives is to develop imgation methods for at least one upland crop.

Dr. Agulto commented that the system they are working on, the UTRIS, was designed for rice but was also devoted to upland crops. They like to document the additional facilitiesthat were put up by farmers for them to grow upland crops. He further stated that they are willing to go to other systems which were designed for rice but which are being used by the farmers for crop diversification.

Engr. Moya commented that maybe the size of the optimum turnout service area is directly related to the number of users in the system. The average farm size at LVRIS is only 0.1-0.15 ha. so that in a 4-ha turnout service area, there are already 30 farmers competing for a single turnout.

In summary, the discussion led to the identification of the following research areas/ activities which can further be tackled in the remaining life of the project or by other projects which may be conducted:

a. Weekly monitoring of volume of production and price fluctuation of diversified crops, i.e., onion to get a better information on how these affect the profitability of farmers in a given season.

b. Quantification of the management cost that is involved in crop diversification, from the point of View of both the farmers and the NIA.

c. Socio-economic dimension of irrigation fee changes.

d. Rehabilitation cost to accommodate diversified cropping.

e. Use of simulation models in irrigation systems.

f. Assessment of facilities put up by fanners to accommodate diversified cropping.

g. Improvement of the regression models related to turnout service areas.

h. Study on other crops with potential for crop diversification.

Planning lor Field Testing

Among the activities that can be further tested are the following:

1. One study is to look at the adaptability of soybeans in ARIP and BARIS since there is the initiative in providing the necessary incentives to grow this particular crop. This would give the opportunity to look at the field condition requirement of soybeans in terms of irrigation and in terms of the operation of the system as a whole. Since soybean needs only one flushing during the season and the Irrigation Superintendent of ARIP and BARIS has assured the delivery of irrigation water, soybean could be a potential crop if the farmers are willing to grow it in the system.

2. In considering the pctential of other crops, the improved open pollinated som which has relatively lower input requirement can be tested.

3. With regard the use of incomplete gamma function, its applicability has to be ascertained, and careful assessment made of the assignment of the probability levels with which to depend on and that would be applicable for operational purposes.

4. The applicability of the computer aided mapping program as developed by Mr. Cablayan to other irrigation system still has to be verified. Training NIA staff for the use of the package then follows.

5. Procedures that would make water distribution more equitable for ho'h rice and non-rice could be tested at LVRIS since it has a better set of control facilities and structures relative to other sites in Luron.

Synthesis (By Mr. *C.* Abernethy)

Mr. Abernethy stressed the need for the adoption a multidisciplinary approach to the issues regarding crop diversification. Five sectors that have to be taken together for the success of crop diversification are 1) the agronomic and agricultural; 2) economic; 3) social; 4) engineering, and 5) institutional sectors. The agriculture sector answers the question of what can grow in a particular place. The economic sector deals with the usefulness of the crop or the availability of market. The social question concerns the farmers. Will the farmer be satisfied with that particular crop? The fourth area of concern, the engineering aspect, deals with the modifications of existing facilities to be able to facilitate the production of the crop and to supply the needed water. And lastly, the institutional question concerns the need for the fresh institutions or modifications of existing ones.

There is a great concern with the seeming isolation of the Philippines from the rest of the world. Highly diversified cropping systems are very common and there is much to be learned from the experience of other countries. The utilization of international literature to prevent reinventing the wheel is necessary.

Regarding the national objectives of trying to promote crop diversification, the government has a strong interest in promoting the capacity to diversify leading to a more flexible agriculture. Consequently, in cases of over supply of rice in other countries, Philippine irrigated agriculture can make rapid changes.

With regard to water saving, it is wrong to think that rice is a water wasteful crop. There is a need to increase productivity of water from 300g per cubic meter to 500 to 700 g per cubic meter. We should not lock ourselves into rice based cropping systems.

It is doubtful whether reducing the irrigation fees really acts as an incentive to diversified cropping. If a person feels that more water will benefit his crop, then he would go for more water because of the importance of the crop output. The fees is just a few percent of the total budget.

The farmer behavior is much more affected by prices. In the presentation, rice has a fairly stable profitability while the alternative crops varied greatly. A study of the market forces for the remaining time of the project may be worthwhile. The amount that the market can absorb, at least at the level of import substitution and the market fluctuations in both time and space must be determined.

The main concern is the question of the farmer and his behavior. Questionnaires to get the rationale of why farmers behave as such have to be carefully structured or else one will get faulty answers.

Regarding farm sizes and the influence of that parameter upon the farmer flexibility of decision making, it is felt that in areas with very small landholdings, the need to provide a basic cereal subsistence crop is dominant and it is very hard to get farmers into alternatives in those circumstances.

It is doubtful if the denial of water to promote non-rice crops is the right strategy. Forcing farmers to do things that otherwise they wouldn't do, i.e., by denial of water or by some compulsive action, may not bring the right result. The agency should let the irrigation organization know what to expect in terms of water delivery and let the individual farmers choose what crop to plant.

With regard the engineering questions, the need for drainage should also be emphasized. Diversified crops need more drainage and cannot stand waterlogging. Water tables need to be maintained at some lower depths or else we do not get successful performance of the alternate crops.

Another major variation is with regard the operating rules. If a more flexible system is to be promoted, bow do the operating rules be changed.

Reactions/Discussion on the Synthesis

Dr. Miranda reacted to the issues raised by Mr. Abernethy. As regards water sharing, he said it should be included as a goal. In Indonesia, in the event of limited amount of water, there was an attempt to spread it as well as they could by reducing the rice area so that the whole command areacould be covered. He said that four times as much area for non-rice could be covered with the amount that would have been provided with rice. He further stressed that water sharing can be used as a selling point in terms of increasing production, increasing income and providing more equity.

Relating the farm size to the adoption of crop diversification, it is observed that what is happening in the Ilocos Region is the reverse of the statement that the smaller the area, the lesser the chance for crop diversification. The reasons given was the need of the farmers to maximize income they could derive from the land and the excess labor which could be utilized if farmers plant labor intensive crops.

On the water denial issue, Dr. Miranda said there are areas in Cotabato in the South and in Isabela in the North which produce corn in both seasons. So whenever an area becomes irrigated, the area becomes converted to rice which essentially reduces the production of corn. When the system becomes operational, and water becomes available, the basic assumption of farmers is that it is for rice so that areas not provided with water automatically plant corn.

Dr. Miranda agreed with the comments regarding drainage. He said that in all the presentations, drainage was not really emphasized. He cited his observations in Malaysia where smaller systems, where water for rice is not assured even during the wet season, are able to grow non-rice crop by installing drainage facilities only.

Dr. Undan commented on the management effort during the dry season as being 4 to 5 times that during the wet season. He stressed that both the wet and dry seasons have to be looked at as a continuum. During the wet season, the problem is more on the excess water; the system personnel have to attend to the problem of controlling this excess water. Maintaining the canals also requires more time since cutting weeds along the canals is a big job. During the dry season, the area coverage is lesser and the same personnel working during the wet season have lesser area jurisdiction. He doubted whether these situation is the same in terms of management of Philippine systems.

Dr. Valera suggested that if **IIMI** can make some sort of a measure or an indicator to show the differences as mentioned by Dr. Undan, we might be able to highlight the incremental effects in trying to irrigate non-rice and comparing rice and non-rice crops in the dry season.

National Workshop on Irrigation Management for Diversified Cropping

Wednesday, 5 October 1988

0800 Registration

0845 Opening Remarks
Master of Ceremonies: Dr. Amado R. Maglinao, Project Coordinator
IIMI-IRRI Collaborative Research Project

National Anthem

Message: Dr. Roberto L. Lenton, Director General, International Irrigation Management Institute (IIMI)

Message: Dr. Ramon V. Valmayor, Executive Director, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD)

Message: Engr. Edilberto B. Payawal, Manager, Systems Management Department, National Irrigation Administration (NIA)

Message: Dr. Manuel M. Lantin, Assistant Secretary for Research and Extension, Department of Agriculture (DA)

Workshop Rationale and Objectives: Dr. Alfredo B. Valera, Resident Scientist, IIMI-Philippines

0950 Socio-Technical Issues in Diversifying Rice-Based Irrigation Systems
Engr. Tolentino B. Moya and Dr. Senen M. Miranda, IIMI

SESSION I IIMI's Irrigated Crop Diversification Research
Moderator: Dr. Senen M. Miranda, IIMI
Rapporteur: Dr. Alfredo B. Valera and Engr. Gregorio C. Simbahan, IIMI

1020 Irrigation Management for Diversified Cropping: Opportunities for Learning and Improvement
Dr. Alfredo B. Valera, Engr. Danilo M. Cablayan and Mr. Jacinto Alexis B. Elegado, IIMI

1045 Methodology for Identifying Parts of Systems Suitable for Crop Diversification During the Dry Season
Engr. Danilo M. Cablayan, IIMI and Engr. Carlos M. Pascual, Mariano Marcos State University (MMSU)

1110 Overview of Crop Diversification in the Upper Talavera River Irrigation System
Dr. Honorato L. Angeles, Central Luzon State University (CLSU)

On-farm Water Management Practices for Upland Crops
Dr. Ireneo C. Agulto, CLSU

On-farm Land Preparation Practices for Irrigated Diversified Crops
Dr. Miguel L. Aragon, CLSU

Profitability Analysis of Rice and Onions Planted During the Dry Season Under Irrigated Conditions
Dr. Eduardo G. Marzan, CLSU

1310 Optimum Farm Ditch Density for Irrigating Diversified Crops
Engr. Carlos M. Pascual, MMSU, Mr. Gregorio C. Simbahan and Engr. Arturo N. Francisco, IIMI

1335 Comparative Economic Analysis of Diversified Crops Under Irrigated Condition and Their Irrigated Performance versus Irrigated Rice
Ms. Margarita P. Caluya and Ms. Charito G. Acosta, MMSU

1400 Production, Credit and Marketing Schemes of Farms in ARIP, BARIS and MCIS, South Cotabato
Ms. Purisima G. Bayacag, University of Southern Mindanao (USM)

1425 Socio-Economic and Water Management Practices Affecting Diversified Cropping Among Farmers Served Within the TASMORIS Area
Dr. Alfredo S. Reyes, Pampanga Agricultural College (PAC) and Engr. P. Dionisio R.E. Reyes, IIMI

1450 Implications for Policy of the Studies on Profitability of Irrigated Non-Rice Crop Production: A Synthesis
Dr. Marietta S. Adriano, National Economic Development Authority (NEDA)

SESSION 11: Related Research on Irrigated Crop Diversification
Moderator : Dr. Edward Martin, IIMI
Rapporteur: Engr. Danilo Cablayan and Mr. Jacinto Alexis Elegado, IIMI

1540 The NIA-JICA Diversified Crops Irrigation Engineering Project: Background, Objectives and Concerns
Engr. Serafin Palteng, NIA and Mr. Masao Morikawa, Japan International Cooperation Agency (JICA)

1605 Crop Diversification: Problems and Prospects in Partially Irrigated Rice-Based Farming Systems
Mr. Hermenegildo C. Gines, IRRI, Engr. Tolentino B. Moya, IIMI, Dr. R.K. Pandey and Dr. Virgilio Carangal, IRRI

1630 High-frequency Basin Irrigation Design for Non-rice Crops in Ricelands
Dr. George J. Moridis and Engr. Manuel M. Alagcan, IRRI

1655 The Micro-Economics of Crop Diversification in a Diversion Irrigation System: A Progress Report from the UTRIS
Dr. Prabhu Pingali, Mr. Policarpio B. Masikat and Ms. Piedad F. Moya, IRRI

1720 Successful Crop Diversification in Irrigated Rice Farms: Development of a Cognitive Decision Making Model
Dr. Anna M. Gonzales-Intal and Dr. Jaime B. Valera, UPLB

1745 The Economics of Diversifying into Irrigated Non-Rice Crops in the Philippines
Dr. Leonardo A. Gonzales. IRRI

IS10 Irrigation Investment and Crop Diversification: A System-level Analysis
Mr. Ricardo A. Guino and Dr. Leonardo A. Gonzales, IRRI

1835 Nestlé Soya Farm's Perspective on the Potential of Soybean for Crop Diversification in Irrigated Areas.
Mr. Alexander R. Madrigal, Nestle Philippines, Inc.

Thursday, 6 October 7988

SESSION 111: Wrap-up/Discussion of Sessions I and II
Moderator : Dr. Senen M. Miranda, IIMI
Rapporteur : **Engr.** Raul B. Alamban, PCARRD, and **Engr.** Rufino S. Soguilon, IIMI

0800 Presentation of Synthesis and Recommendation (Opportunities, Constraints, Research Policy)
Mr. Charles Abemethy, IIMI

0830 Reactions

NIA- **Engr.** Apolinario T. Mempin, Manager, Institutional Development Division, Allah River Imgation Project, National Imgation Administration

DA - Mr. Renato Bayaca, Bureau of Agricultural Research, Department of Agriculture

NEDA-Dr. Marietta S. Adriano, Director, Agriculture Staff, National Economic Development Authority

0900 OPEN FORUM/DISCUSSION

SESSION IV: Review of the Publication ***State of the Art/Abstract Bibliography*** on ***Water Management for Crop Diversification***
Moderator : Dr. Amado R. Maglinao, IIMI
Rapporteur: **Engr.** Ester Vergara, PCARRD and Engr. Isidro B. Teleron, IIMI

1015 Presentation of the ***State of the Art/Abstract Bibliography on Water Management for Crop Diversifcation in Irrigated Rice-Bared Cropping Systems***
Dr. Rodolfo **C.** Undan, CLSU, Dr. Diosdado A. Carandang, Dr. Roberto Ranola, UPLB, and Dr. Soledad Mina, CLSU-IRRI

SESSION **V** : Guidelines on Irrigation Management Practices for Crop Diversification
Moderator : Dr. Edward Martin, IIMI
Rapporteur: Ms. Redia N. Atienza, PCARRD and Engr. Arturo **N.** Francisco, IIMI

1330 Guidelines for **Production** and Irrigation Management of Selected Upland Crops
Dr. Abraham A. Caoili, UPLB

1400 Proposed Guidelines for the Management and Operation of Imgation Systems with Diversified Cropping
Dr. Alfredo B. Valera, Engr. **Danilo M.** Cablayan and Mr. Jacinto Alexis B. Elegado, IIMI

1430 Agro-Institutional Development Implementation for Crop Diversifcation at MA-ARIP
Engr. Apolinario T. Mempin, NIA

Irrigation Management of Allah River Irrigation Project
Engr. Honorato O. Bienes, Engr. E. A. Golingay and Engr. R. de Guzman, NIA-ARIP

Operation of the Banga River Irrigation System
Engr. Honorato O. Bienes and Engr. O. A. Tibang, NIA-BARIS

Water Management Scheme at the Upper Talavera River Irrigation System
Engr. Arturo Guzman Arocena, NIA-UPRIIS

Operation and Maintenance of the Laoag-Vintar River Irrigation System and Bonga Pump No. 2
Engr. Alfredo Lorenzo and Engr. Nemesio Ines, NIA-INIS

1545 OPEN FORUM/DISCUSSION

Friday, 7 October 7988

SESSION VI: Planning Workshop
Moderator : Dr. Alfredo B. Valera, IIMI
Rapporteur: Dr. Amado R. Maglinao, IIMI and Ms. Redia N. Atienza, PCARRD

0800 Planning for Component Researches

1015 Planning for Field Testing

1300 Synthesis/Recapitulation/ Wrap-up of Session
Mr. Charles Abernethy, IIMI

1400 OPEN FORUM/DISCUSSION

1530 CLOSING REMARKS
Dr. Alfredo B. Valera, IIMI

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