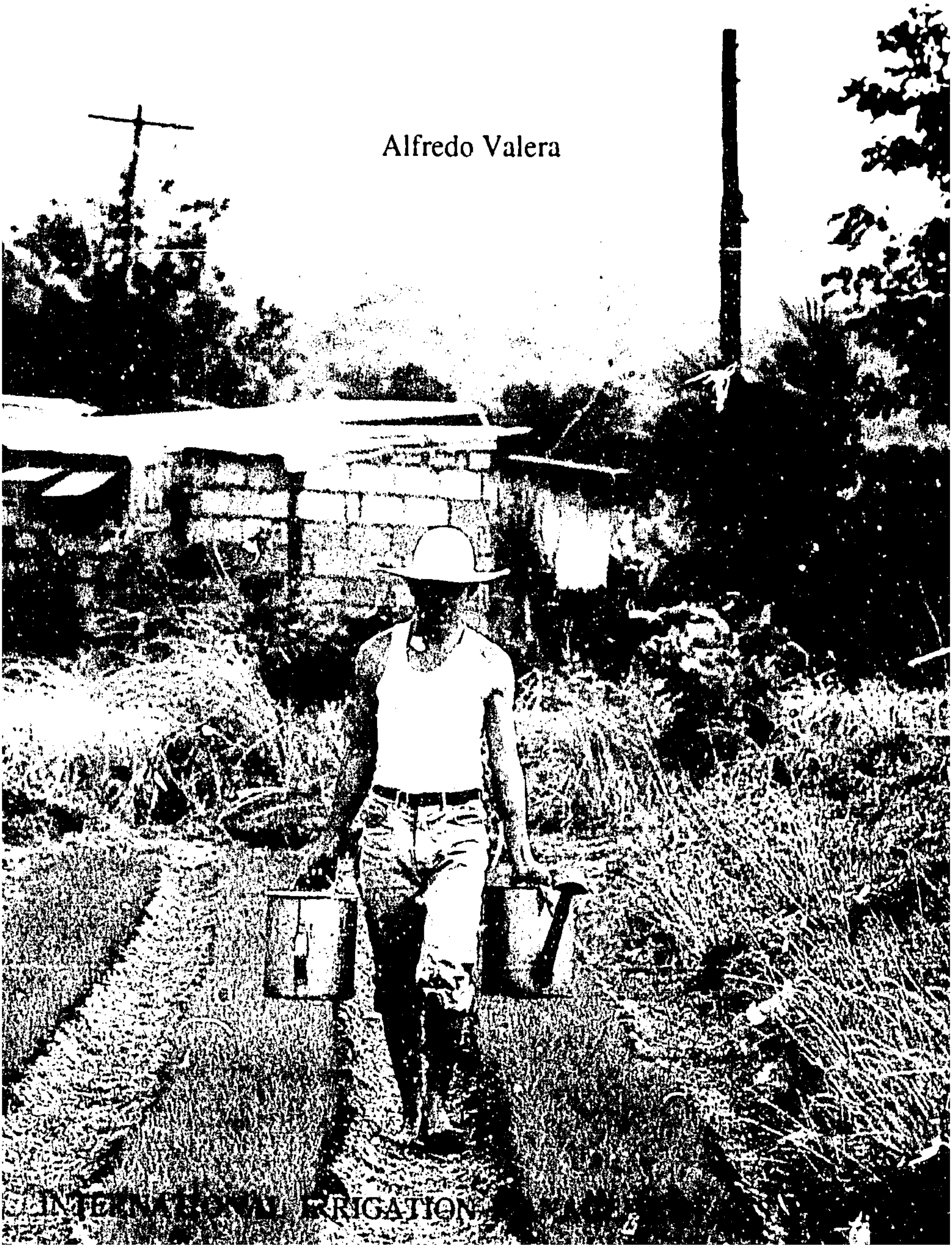
Irrigation Management for Diversified Cropping in Rice-Based Systems in the Philippines

Alfredo Valera



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2

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Cover photograph by John Colmey: Onions, constituting part of the diversified cropping system, being hand irrigated by a Philippine farmer in Luzon.

3

Contents

4

List of Figures

List of Tables

Foreword

WHEN IIMI BEGAN its activities in 1985, the Philippines was one of the first countries where it established a resident office. Dr. Alfredo Valera was the first head of that office. This book presents in a readily accessible form the principal findings of over four years of field research which Dr. Valera organized thereafter, in close collaboration with several Filipino universities and other national organizations.

In the mid-1980s a prominent question for irrigation management throuhgout southeast Asia was how to respond to their systems' own success in delivering substantially increased levels of per capita rice production. World rice prices had fallen steeply, and farmers' incomes were under pressure. Both diversification (switching from rice to other crops) and intensification (increasing the planting of non-rice crops in the dry season) seemed to be indicated.

National efforts to promote such outcomes should be seen in the context of helping farmers to sustain and improve the standard of living which they can derive from irrigated agriculture. The overall goal is to develop as far as possible flexible, market-responsive systems in which farmers can exercise cropping choices that will optimize their economic situation.

The studies recorded here show clearly the combination of technical constraints that have to be overcome: irrigation systems whose physical design for water delivery and disposal is created with rice production as the major goal; appropriateness of soils; suitability of alternative crop choices. They also delineate the important socioeconomic dimension. Many of the possible alternative crops offer the chance of attractive cash returns, but they also require the acceptance by farmers of higher levels of risk. The investment in input costs may be much higher than for rice; and the market price of the alternative crop may be much more volatile.

These issues are shared throughout the rice-growing regions of south and southeast Asia, nine of whose coutries are now members of the

9

Network on Irrigation Management for Crop Diversification in Rice-Based Systems, which IIMI coordinates. Dr. Valera's detailed review of the problems manifested in one of those countries will be of value throuhgout the region.

Charles L. Abernethy
Senior Technical Advisor

Acknowledgements

THE RESEARCH STUDIES conducted would not have been made possible without the generous cooperation from the staff of several Philippine government agencies and state colleges and universities. The major collaborator was the National Irrigation Administration (NIA). From the Administrator to the ditchtenders, the openness and friendship offered in making the studies possible were immeasurable. In particular, Mr. Salvador Salandanan, Chief of the Research and Development Division, System Management Department, was most helpful in providing not only data and information, but support and insights into NIA's way of operation at the Central Office and in the system offices that were relevant to the studies. To him and the other NIA staff at the Central Office and at the Upper Talavera River Irrigation System (UTRIS) and the Laoag-Vintar-River Irrigation System (LVRIS), the author expresses his gratitude.

The other government agencies that directly supported the studies were the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), Bureau of Agricultural Research, Department of Agriculture, and the staff of the Agriculture Division of the National Economic Development Authority. In particular, PCARRD was most invaluable in providing office space, staff resources and other facilities that enabled the research to be more relevant to the national effort.

The researchers and staff that collaborated in the studies were from the Mariano Marcos State University, University of the Philippines at Los Banos, Central Luzon State University, Pampanga Agricultural College, Southern Mindanao State University, and Isabela State University. They deserve recognition for their efforts and contributions to the studies.

The major donors that supported the studies were the Asian Development Bank (ADB) and the Rockefeller Foundation to whom the author is grateful. The efforts of the ADB staff, particularly of Messrs. G.

Walter and K.L. Lim, resulted in the majority of funding for the studies. The Director of Agriculture, Dr. Robert Herdt of the Rockefeller Foundation provided generous support to the International Irrigation Management Institute (IIMI) and the International Rice Research Institute (IRRI) for carrying out collaborative studies, whose results were used in this paper.

Members of the staff of the Water Management and Soils Departments of IRRI were also instrumental in complementing the studies conducted by IIMI with funds from the Rockefeller Foundation. The results of the studies in the farm level used in this paper were undertaken by IRRI research staff. Acknowledgement is hereby made to these staffs.

To the IIMI - Philippine research staff, Danilo Cablayan, Gregorio Simbahan, Tolentino Moya, Arturo Francisco, Alexis Elegado, Ding Teleron III, and Rufino Soguilon who undertook the IIMI studies; to the IIMI - Headquarters staff, particularly Dr. Senen Miranda, who wholeheartedly supported the efforts that went into these studies, and to Mr. Kingsley Kurukulasuriya who edited this paper, the author wishes to express his gratitude.

But most of all to the countless farmers in the irrigation systems who generously answered the survey questions, provided invaluable insights and wisdom in farming, and to whom the benefits of this paper should ultimately go to, the author is indeed grateful.

Alfredo Valera
Irrigation Specialist
IIMI

CHAPTER I

Introduction

AGRICULTURAL DIVERSIFICATION IS evolving as an attractive alternative in agricultural development due to declining worldwide commodity prices of staple crops, particularly rice, instability and unsustainability of agricultural production systems based on single crops, and declining income of the rural sector. Diversified cropping is, therefore, one of the major components for improving agricultural productivity.

With the increasing production of rice and its decreasing price in the 1980s, crop diversification appeared to be an attractive alternative in increasing agricultural productivity and rural incomes, particularly in Southeast Asia. However, there is a counterargument which cites rapidly increasing population and faltering rice production. Notwithstanding this counterargument, alternative strategies based on long-run projects are carefully considered by policymakers in the region to find out the consequences of overproduction of rice and the sustainability of single crop production systems.

It is the farmers who make the final decisions which lead to crop diversification but agricultural policies and government agencies provide the technical and economic environments that allow farmers to make such decisions (Timmer 1990). In irrigated environments, farmers have the advantage of having better resources (water, credit, extension services, marketing facilities) in diversifying crops compared to those in the rain-fed environments. Despite these resources, there exists constraints for the effective adoption of diversified cropping.

In most of Southeast Asia, irrigation systems were built and designed specifically to irrigate rice in the wet and dry seasons. Difficulties in utilizing these systems for non-rice or upland crop production are to be expected even in the dry season. Constraints in the technical, institutional and economic aspects of diversified cropping have to be mitigated.

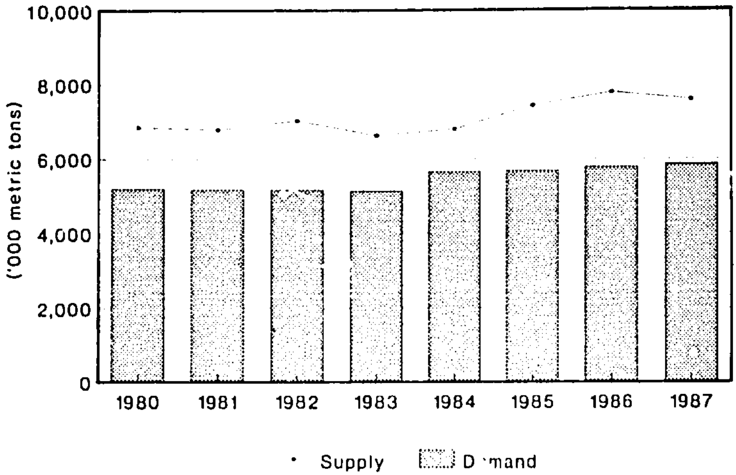
The Philippines is one country in the region where large investments in irrigation have contributed to increases in rice production. These investments were made in response to the increasing price of rice and population growth and also with the ultimate aim of self-sufficiency and food security. The present policy in food security is to maintain a buffer stock of rice enough to cover 180 days (Table 1 and Figure 1).

Table 1. Rice production and imports (in 1,000 metric tons), the Philippines, 1970-1987.

Year	Production	Net (+)Imports/(−)Exports
1970	3,472.9	186
1971	3,315.1	595
1972	2,869.5	316
1973	3,638.2	205
1974	3,679	145.3
1975	4,003.7	55.2
1976	4,190.5	15.6
1977	4,481.7	13.4
1978	4,678.1	− 38
1979	5,093.4	− 23.6
1980	5,020	− 175
1981	5,279.1	− 11
1982	5,024.8	− 29
1983	5,330	162
1984	5,120.1	189.7
1985	5,758.9	538.1
1986	6,047.4	2.1
1987	5,585.1	− 111

Sources: 1970-1983 data; David, C. et al. 1986.
1984-1987 data; Bureau of Agricultural Statistics 1988. 1987 data are preliminary.

Figure 1. Supply and demand for rice in the Philippines, 1980-1987.



Note: The supply figures consist of imports, production, and carryover stock of rice.
Source: Bureau of Agricultural Statistics 1988.

Overproduction in rice is not an attractive prospect due to the declining world price of rice (Pingali 1990). Furthermore, the Philippines has the comparative advantage of producing both rice and non-rice crops (Gonzales 1984). Diversified cropping in irrigated areas is considered feasible to increase dry-season productivity and rural incomes.

This paper presents the results of the research carried out to examine selected technical, institutional and economic issues that impinged on farmers' decisions to shift from rice to non-rice crop production in several irrigation systems in the Philippines, particularly in the dry season. These issues were examined with emphasis on the consequent irrigation management practices by farmers and irrigation agency staff and they were found conducive to non-rice crop production.[1] Consequently,

[1]Irrigation management is the process that institutions or individuals employ to set objectives for irrigation systems; establish appropriate conditions; and identify, mobilize, and use resources to attain objectives while ensuring that these activities are performed without adverse effects (IIMI 1989).

promising irrigation management practices were also identified and field-tested.

The paper draws mostly from primary data gathered through the study on Irrigation Management for Diversified Crops funded by the Asian Development Bank (ADB) as a technical assistance grant (TA No. 859 PHI) to the Government of the Philippines, with the National Irrigation Administration (NIA) being the main recipient of the grant. The International Irrigation Management Institute (IIMI) implemented the study with NIA, the Philippine Council for Agriculture, Forestry, Natural Resources Research and Development (PCARRD), and the Bureau of Agricultural Research (BAR). Secondary data are also used in this paper, drawing primarily from the research papers of the IIMI-IRRI Collaborative Project on Irrigation Management for Rice-Based Farming Systems, funded by the Rockefeller Foundation. The research was undertaken from 1986 to 1990.

CHARACTERISTICS OF IRRIGATION SYSTEMS

Six systems were selected for the studies on crop diversification (Table 2). Two systems were located in Mindanao and the rest in Luzon (Figure 2). The systems in Mindanao were selected based on their potential for diversification and the administrative consideration requested by ADB in supporting the study (IIMI 1990). Components of the studies funded by ADB were carried out in all of the systems except the San Fabian River Irrigation System (SFRIS).

The IIMI-IRRI Collaborative Project used both the Upper Talavera River Irrigation System (UTRIS) and the Laoag-Vintar-River Irrigation System (LVRIS) as their locations of study with the additional location at SFRIS. The ADB-supported study was carried out from 1986 to 1989, and the IIMI-IRRI Collaborative Project from 1985 to 1990. Furthermore, this project deliberately used the UTRIS and LVRIS study locations, to build on whatever had been accomplished in the ADB-supported study.

16

Table 2. Characteristics of irrigation systems selected for crop diversification studies, 1986-1989.

Irrigation system	Allah River Irrigation Project (ARIP)	Banga River Irrigation System Pump No. 2 (BARIS)	Bonga River Pump Irrigation System No. 2 (BP#2)	Laoag-Vintar River Irrigation System (LVRIS)	San Fabian River Irrigation System (SFRIS)	Upper Talavera River Irrigation System (UTRIS)
Location	Southern Mindanao	Southern Mindanao	Northern Luzon	Northern Luzon	Northern Luzon	Central Luzon
Province	South Cotabato	South Cotabato	Ilocos Norte	Ilocos Norte	Panga-sinan	Nueva Ecija
Type of system	-- Run-of-the-river---		River pumping	------Run-of-the-river-------		
Command area (ha)	7,311	3,360	674	2,377	4,265	4,650
Soils	---------------- Alluvial -------------------------					
Texture	--Sandy to clay loam--		--------- Sandy to clayey ------------			
Cropping pattern	----Rice-rice ------ ----Rice-corn------		Rice-garlic Rice-rice-mungbean Rice-other vegetables		Rice-tobacco Rice-rice	Rice-onion Rice-rice
Rainfall pattern	----Type IV------		------------- Type I --------------			

Notes: Cropping patterns only for dominant crops.

Type I - Two distinct seasons: dry from November to April and wet during the rest of the year.

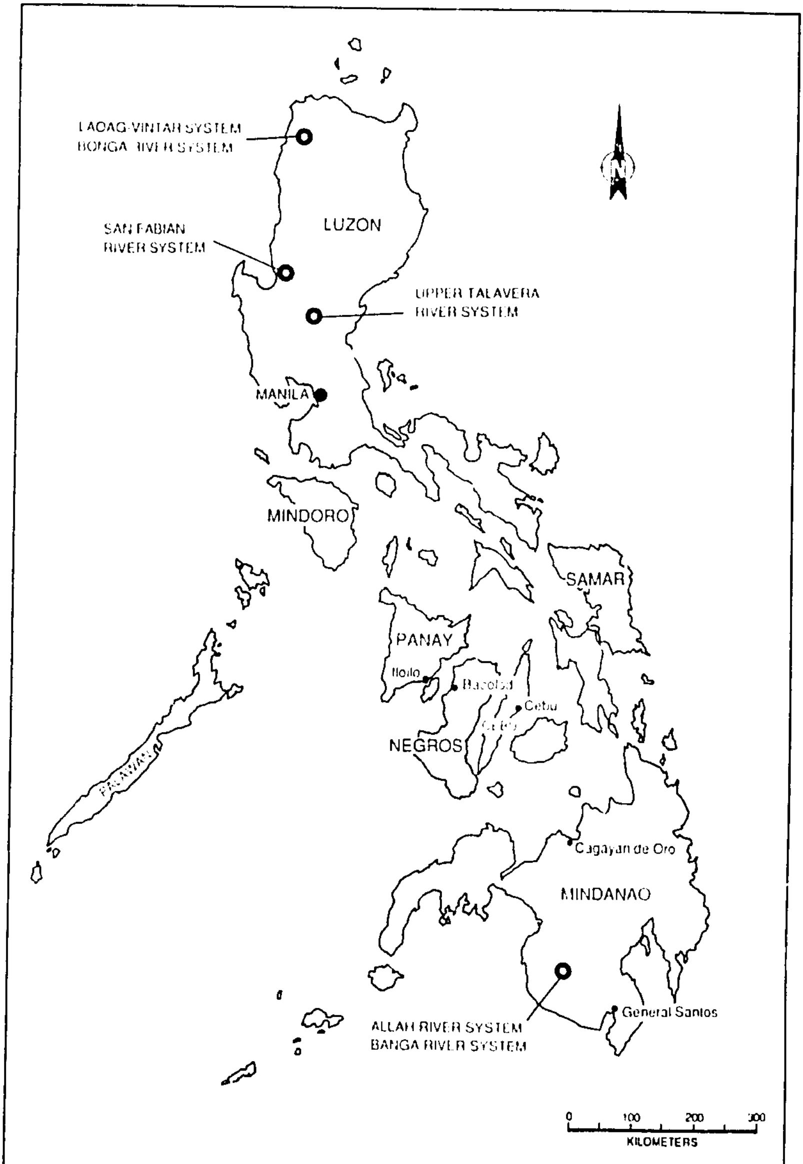
Type II - No dry season; distinct maximum rainfall from November to January.

Type III - Seasons not distinct and relatively dry from November to April and wet during the rest of the year.

Type IV - Rainfall more or less distributed throughout the year.

Source: Miranda, 1989.

Figure 2. Locations of selected irrigation systems in the Philippines.



Source: IIMI 1990.

18

All of the systems derived their water supply from the river without any storage capability. The Bonga River Pump Irrigation System No.2 (BP#2) is a pumping scheme and all other systems rely on the diversion of river water by gravity from a barrage. The soils are of alluvial origin. However, the texture of soils in the Mindanao systems is sandy to clay loam while in the Luzon systems it is sandy to clayey.

Two cropping patterns are practiced during the wet and dry seasons. Except in some areas in LVRIS, a third crop of mungbean follows rice or garlic as shown in Table 2. The mungbean crop subsists primarily from residual moisture and is generally broadcasted after the harvest of the main dry-season crop. The corn crop in the Mindanao systems is not irrigated but subsists mainly on rainfall and seepage from adjacent rice fields.

CHAPTER 2

Results of Studies

THERE ARE MANY factors affecting crop diversification in irrigated areas in the dry season. Three of these which are technical, institutional and economic in nature are discussed in this chapter and the following chapters. A conceptual model is used to illustrate the interrelationships of these factors (Figure 3). The paper does not intend to provide definitive answers or causality of factors leading to crop diversification. However, it points out reasonable explanations of the practices of farmers and irrigation staff in non-rice crop production in the dry season. A set of irrigation management procedures was also developed and then field-tested.

Among the technical issues examined were land suitability *(soil and topography)*, and *water supply;* among the institutional issues, *on-farm water management* and *irrigation system management;* among issues coming under both physical and institutional dimensions, *reliability* and *distribution of irrigation water supply;* and among the economic issues, *input and output markets* and *profitability*. These issues were examined to assess their influence on farmers' decisions to diversify to non-rice crops in the dry season.

LAND SUITABILITY

Suitability of soil and topography is the major characteristic favoring dry season crop diversification in rice-based irrigation systems. Based on land classification alone, there are approximately 207,962 ha of land irrigated by the NIA systems in the Philippines, which are suitable for non-rice crop production. This accounts for about a third (34.5%) of the entire command or service area of the NIA systems (Table 3). These are soils classified as dual and diversified lands in both of which classes rice

20

and non-rice crops can be productively grown. In the dual land class seepage and percolation rates are high but do not exceed 8 mm/day while in the diversified land class these rates exceed 8 mm/day.

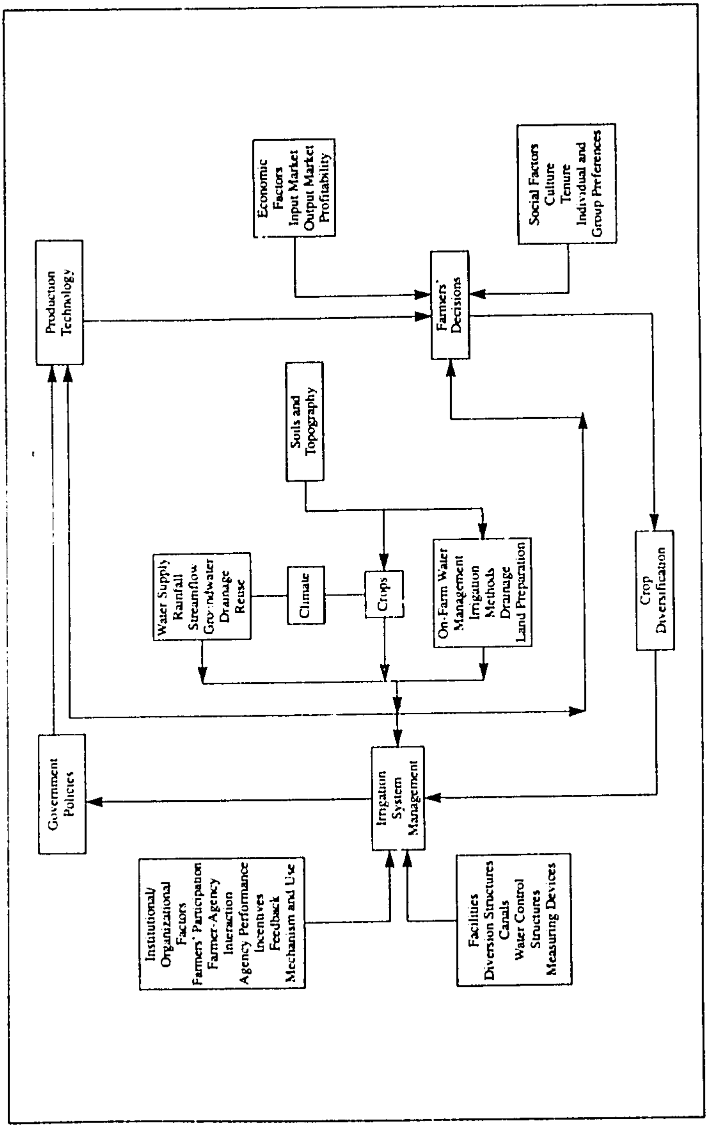


Figure 3. Interrelationship of factors affecting crop diversification.

Source: Maglinao et al. 1990.

Table 3. Dual and diversified croplands in the national irrigation systems (NIS) of the Philippines.

Region	Service areas of NIS (ha)	Dual and diversified croplands* (ha)	Percent of service area
1	46,082	32,965	71.5
2	140,962	30,110	21.4
3	175,285	60,770	34.9
4	54,238	27,296	50.3
5	16,466	4,264	25.9
6	53,461	7,678	14.4
7	none	–	–
8	16,860	none	–
9	12,449	none	–
10	20,013	6,820	34.1
11	34,711	24,291	69.9
12	27,426	13,768	50.2
Total	597,953	207,962	34.8

*Land suitable for both rice and diversified crops.
Source: IIMI 1990.

However, rice is the only crop irrigated in the wet season in all irrigation systems in the Philippines.[2] Because of the dominance of heavy clay soils in these systems and an abundant supply of water from rain, these systems were designed and built for irrigating rice. Despite the suitability of soil and topography, only 2 percent of the entire NIA irrigated area is planted to non-rice crops in the dry season (PCARRD 1988).

The presence of a hard pan in the plow layer of rice soils and the puddled or unstructured condition of the soils tend to go against the productive cultivation of non-rice crops, even in irrigated areas with

[2]Some non-rice crops are also irrigated in the wet season, particularly those grown in the plantation areas, but they account for less than 1 percent of the irrigated areas under NIA.

lighter-textured soils. This soil condition results when the field has been cultivated with rice in the wet season for a number of years.

Because of this condition, seasonal soil management activities are required by farmers for non-rice crops (Zandstra 1978). A study based on a survey of farms at UTRIS compared farming operations of double-cropped rice and diversified farms in the dry season. The results indicated that farmers who diversified in the dry season prepared their land differently from purely rice farmers who grew two crops of rice per year (IIMI 1990).

Farmers with lighter-textured soils plowed their land dry during the wet season which had the following major benefits: 1) better weed control, whereby weeds were allowed to germinate and then plowed under; 2) smaller draft power requirement; and 3) better soil condition for growth of the succeeding onion crop in the dry season.

In contrast, primary tillage was done in heavy clay soils under double rice cropping using wetland plowing; in this case too, the germinated weeds were plowed under but the soil was soaked at least a week before plowing which required more draft power due to the sticky nature of clayey soils.

The formation of a hard pan beneath the plow layer was not very much evident in lighter-textured soil. In cases where hard pans were present, they were easily broken up during the primary tillage when land preparation for non-rice crops was undertaken in the dry season. In heavier textured soils, hard pans were found significant enough to prevent percolation in the soil profile.

Besides textural characteristics, the soil bulk density was also found to be influenced by puddling which affected the soil air capacity and hydraulic conductivity (Harwood 1975). However, with the dry plowing practice of farmers for the lighter-textured soils, the bulk density is maintained well within the acceptable limits for suitable upland crop cultivation.

The dry land preparation practice of farmers has evolved from experience gathered from 10 to 35 years in cultivating rice in the wet season and non-rice (onion) in the dry season. Other results of the study included the smaller area farmed (0.6-1.5 ha) for diversified cropping.

For the other systems at LVRIS, the Banga River Irrigation System (BARIS) and the Allah River Irrigation Project (ARIP), the non-rice crops planted in the dry season were garlic, mungbean, lowland potato and corn. The presence of lighter-textured soils was one of the major considerations for crop diversification in these systems (Table 2).

MAPPING TECHNIQUE FOR LAND SUITABILITY

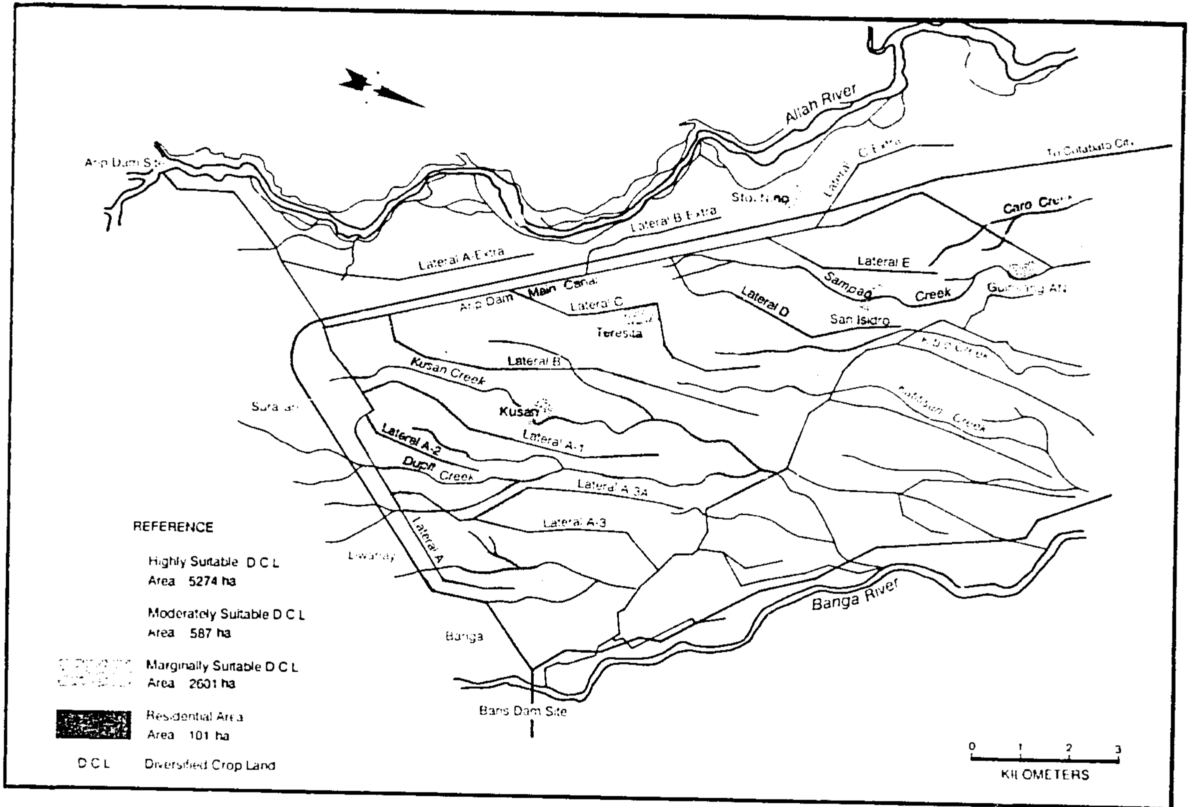
A microcomputer-aided mapping technique was developed to accurately identify parts of the irrigation system suitable for diversified cropping in the dry season (Cablayan and Pascual 1989). This computer program was derived from a Geographic Information Systems (GIS) analysis. Spatial data, particularly soil types, topography, land use and other physical data (irrigation canals, rivers, roads, etc.) were used to determine the suitability of areas for the production of upland crops. These were then spatially represented and digitally captured and linked with one another with the use of a GIS analysis.

An existing mapping program called Mapping Analysis Program (MAP), also GIS-derived, was used as the reference for the development of a better program. This program was tested to map out LVRIS. The main disadvantage of MAP is its large-scale representation of data. The results included errors in encoding due to boundary differentiations between two themes or thematic maps. Furthermore, the calculated areas did not equal the computed areas, when a planimeter was used for measuring the areas. The output map could not be easily understood since it did not show line attributes or names. Each grid cell in the output map was equivalent to 1.5 ha. This program is appropriate for large-scale mapping used in the preparation of regional or provincial maps.

The program developed was called the Computer Aided Mapping Program (CAMP) which afforded more accurate representation. The grid cell unit represented only a third of a hectare. This was accurate enough to delineate, within an irrigation system, parts or areas where upland crops can be productively grown in relation to the different parts of the system. This program was written in the BASIC programming language and developed by the IIMI-Philippine staff.

The CAMP was validated when ARIP was used as the initial irrigation system for a land suitability map (Figure 4). With the use of a plotter (Hewlett Packard series 3000 Plotter or equivalent Roland DC DXY 880A Plotter) and an IBM PC AT microcomputer or its equivalent, an accurate land suitability map can be produced. Of course, this requires accurate maps on soils, land use, and topographic and irrigation systems. The reliability of the output map is dependent on the accuracy of the input maps.

Figure 4. Suitability to irrigated diversified crops during the dry season, Allah River Irrigation Project, South Cotabato, the Philippines.



Source: Cablayan and Pascual 1989.

This land suitability map can be used primarily for planning and also for operational purposes. The operational use of this map will be in delineating areas to be irrigated for rice and non-rice when there is an expected shortfall of irrigation water in the dry season which is often the case in most run-of-the-river systems in the Philippines.

The CAMP can also be used for farm parcellary mapping and weekly mapping of water-adequacy status. The processing of the input maps can be facilitated with the use of a digitizer in addition to the plotter and the AT microcomputer. Presently, a more user-friendly program is being developed with the use of a digitizer. Training of potential users of this program is underway at NIA.

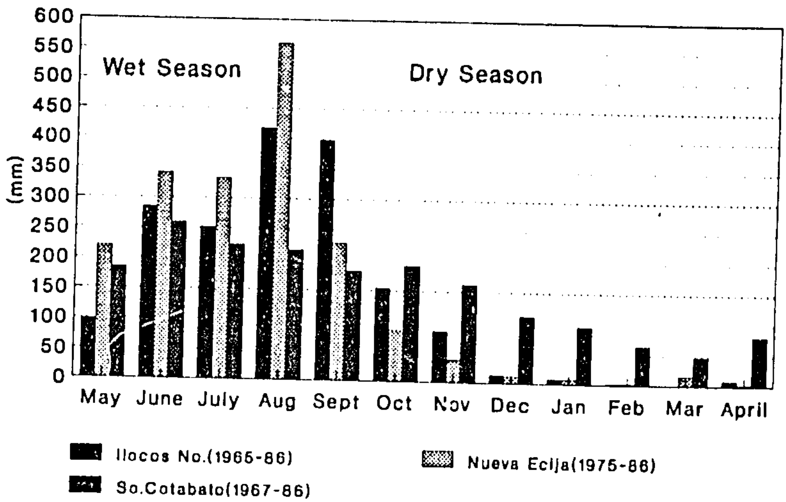
WATER SUPPLY

The cropping pattern in most of the irrigation systems in the Philippines is adjusted to fit the rainfall pattern in the command area of the systems. This is to take advantage of the abundant rain of the wet season for land soaking and to harvest when the rainfall is minimal.

The rainfall pattern for the three provinces indicated the relative magnitude and period of occurrence of rainfall in the systems selected as study sites (Figure 5 and Table 2). With abundant rainfall in the wet season, rice is the main crop even in the South Cotabato systems. It will be very difficult to cultivate non-rice crops in the wet season due to the excessive amount of rainfall received during this period.

There is a contrasting rainfall pattern between the Luzon systems (LVRIS, UTRIS, SFRIS) and the Mindanao systems (ARIP, BARIS). The rainfall pattern in the Luzon systems is classified as belonging to Type I climate with very pronounced wet and dry seasons. The dry season starts in November with rainfall less than 100 mm which is drastically reduced to a negligible amount lasting until April. The rainfall pattern in Mindanao, on the other hand, is classified under Type IV climate with relatively even distribution of rainfall throughout the year. However, with a rainfall of 100 mm or less between December and April this period is still considered as the dry season (Figure 5). It is during this period that non-rice crops are planted and planned for further increase, in irrigated areas in the Mindanao systems.

Figure 5. Mean monthly rainfall at the study sites.



With a monthly average potential evapotranspiration rate of 120 mm, irrigation is very much needed to support a decent crop of rice even in Mindanao where rainfall is limited in the dry season. This limited rainfall does not deter farmers from planting rice despite the soils suitable for diversified cropping. For most farmers, irrigation is synonymous with rice production. This was the case of the project at ARIP. The project was justified partly on the basis that in the dry season a significant portion of the command area would be planted to irrigated non-rice crops (corn). Benefits and projections were made, based on this assumption. Thus, the project costs and benefits were acceptable for funding.

The major flaw of this justification was that farmers were assumed to plant irrigated corn and other non-rice crops in the designated portions of the command area in the dry season. Limited pilot testing demonstrating benefits of upland crop production became the primary means of convincing farmers that diversified cropping was indeed viable. However, this was done only after the system was constructed. Research had been carried out to examine the technical, institutional and economic constraints affecting the irrigation of diversified crops; this was coupled with the pilot-testing efforts to promote upland crop production in the dry season (IIMI 1986). In hindsight, if these tests and research had been carried out before the project construction and their results considered or incorporated in the planning stage of the project they would have been more effective.

One major reason cited by farmers at ARIP for not planting corn and other non-rice crops in the dry season was that the soil was still too wet from the preceding wet season and corn could not be productively grown, unless an appropriate but expensive drainage system was provided. This argument was found to be correct even in the designated areas for diversified cropping (IIMI 1990).

In the Luzon systems, the limited availability of rainfall (though rapidly diminishing) provided farmers with a sufficient water supply for land preparation for the rice crop until the onset of the dry season but it misled them into thinking that the water supply would be sufficient for the entire dry season. This false assumption was due to the abundance of irrigation water during the land preparation stage when some farmers assumed and risked that once they had planted their rice crop, the irrigation agency would be committed or obliged to provide adequate irrigation water throughout the dry season.

With the reduced availability of irrigation water in the dry season, the areas irrigated were drastically reduced in all systems. The area reduction between wet and dry seasons ranged from 70 percent at UTRIS to 27 percent at LVRIS for the Luzon systems and 30 percent at ARIP and 1 percent at BARIS, for the Mindanao systems (Table 4).

A third crop of corn that primarily subsisted on seepage and rainfall was planted at BARIS during the 1987/1988 dry season. This was due to the staggering of the cropping schedule implemented by the NIA staff which resulted in early completion of dry-season rice cropping in some sections of the system. Moreover, hybrid corn seeds were provided on credit to the farmers who volunteered to plant a third crop (IIMI 1990).

In 1988, the wet-season area at BARIS was much less than the dry-season area because of siltation (Table 4). But generally, because of this reduction in water availability in the dry season, farmers in these systems planted both rice and non-rice crops. Both the availability of water and the suitability of soil can be considered as physical determinants of diversified cropping in most of the Luzon systems.

Farmers at the tail end of UTRIS and SFRIS were observed to rely on shallow well pumps for water supply augmentation, particularly toward the middle and later periods of the dry season (Undan et al. 1990). It was

Table 4. Area irrigated at Laoag-Vintar River Irrigation System (LVRIS), Bonga River Pump Irrigation System (BP#2), UTRIS, ARIP, and Banga River Irrigation System (BARIS) for the cropping seasons, 1987-1989.

	LVRIS	BP#2	UTRIS	ARIP	BARIS
Command area (ha)	2,377	674	4,650	7,311	3,360
Wet season 1987	2,220	375	4,116	4,400	1,930
Dry season 1987-1988					
Rice (ha)	970	155	620	3,038	1,750
Non-rice (ha)	643	58	596	27	160
Subtotal (ha)	1,613	213	1,216	3,065	1,910
Cropping intensity	161	87	115	102	114
Wet season 1988	2,251	483	3,936	4,225	1,100
Dry season 1988-1989					
Rice (ha)	994	187	490	4,197	1,794
Non-rice (ha)	595	61	762	29	50
Subtotal (ha)	1,589	248	1,252	4,226	1,844
Cropping intensity	161	108	112	116	88
Wet season 1989	2,377	na	3,900	na	na
Dry season 1989-90					
Rice (ha)	700	na	1,419	na	na
Non-rice (ha)	800	na	574	na	na
Subtotal (ha)	1,500		1,991		
Cropping intensity	163		127		

Notes:

Non-rice crops planted were mostly garlic at LVRIS, onion at UTRIS and tobacco at SFRIS (see Table 2). At UTRIS, areas irrigated by shallow-well pumps are included.
Wet season crop is rice for all systems.
na (in all Tables) = data not available.
The area irrigated at UTRIS includes the San Agustin Extension area.

$$\text{Cropping Intensity} = \frac{\text{Wet Season Area} + \text{Dry Season Area.}}{\text{Command Area}}$$

further observed that the water table in these portions of the systems rose when irrigation water was delivered into the canals.

In all of the system sites, the main source of water was the river from which water was diverted to the command areas. Rainfall and shallow groundwater wells supplemented this supply of water. Shallow wells were pumped, particularly in the tail sections. Where there was rainfall throughout the year, rice was the preferred crop of the farmers. In cases where there was no rainfall in the dry season, rice was planted only in areas with good access to irrigation water; however, the choice of planting rice or non-rice crops depended on the soil type.

CHAPTER 3

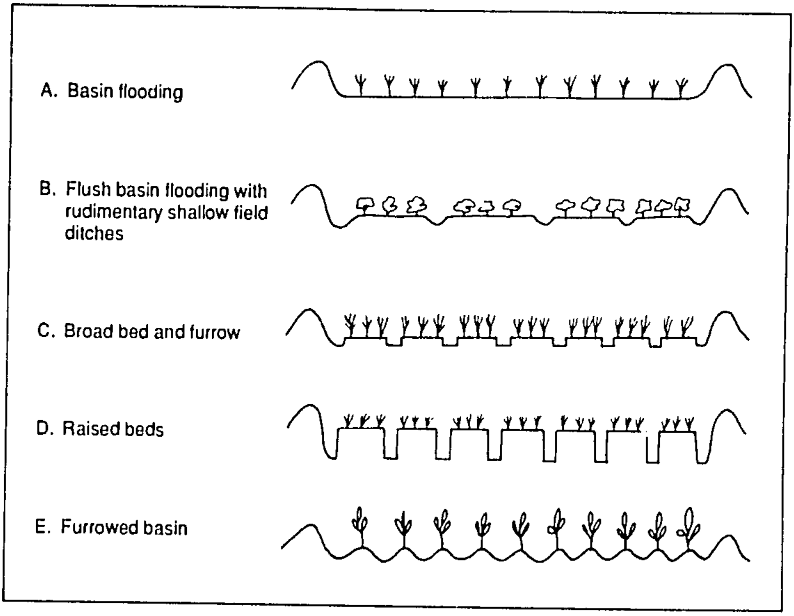
On-Farm Water Management

FARMERS HAVE DEVELOPED effective ways to deal with the process of diversifying to non-rice crops in an irrigated rice environment in the dry season. They have to contend with the layout of the field for cultivating both rice in the wet season and non-rice crops in the dry season. The cultivation of non-rice crops is totally different from that of rice, particularly with regard to irrigation. Several irrigation practices and techniques that are effective in conserving both soil and water have been developed by farmers in these systems.

FIELD PLOT CONFIGURATIONS

To a large extent, the irrigation application practices used by the farmers depend on the rooting depth of the non-rice crops planted. For shallow-rooted crops (20-30 cm) such as onion, garlic and mungbean, the farmers prefer flush-basin flooding arrangement with ditches, broadbed and furrow and raised beds. Mulching with rice straw is used by some farmers for the onion and garlic crops, while for deeper-rooted crops (50-100 cm) such as peanut and corn, the furrowed basin arrangement is used by the farmers mostly in the Mindanao systems (Figure 6). However, for irrigating tobacco which is also deep-rooted, the flush-basin flooding arrangement is used by the farmers at SFRIS (Moya 1990). The only modification is the provision of "baffles" made out of stones in the inlet portion of the basin to dissipate the high flow rate of water applied to the tobacco plot.

Figure 6. Field plot configuration for non-rice crops with rice dikes retained.

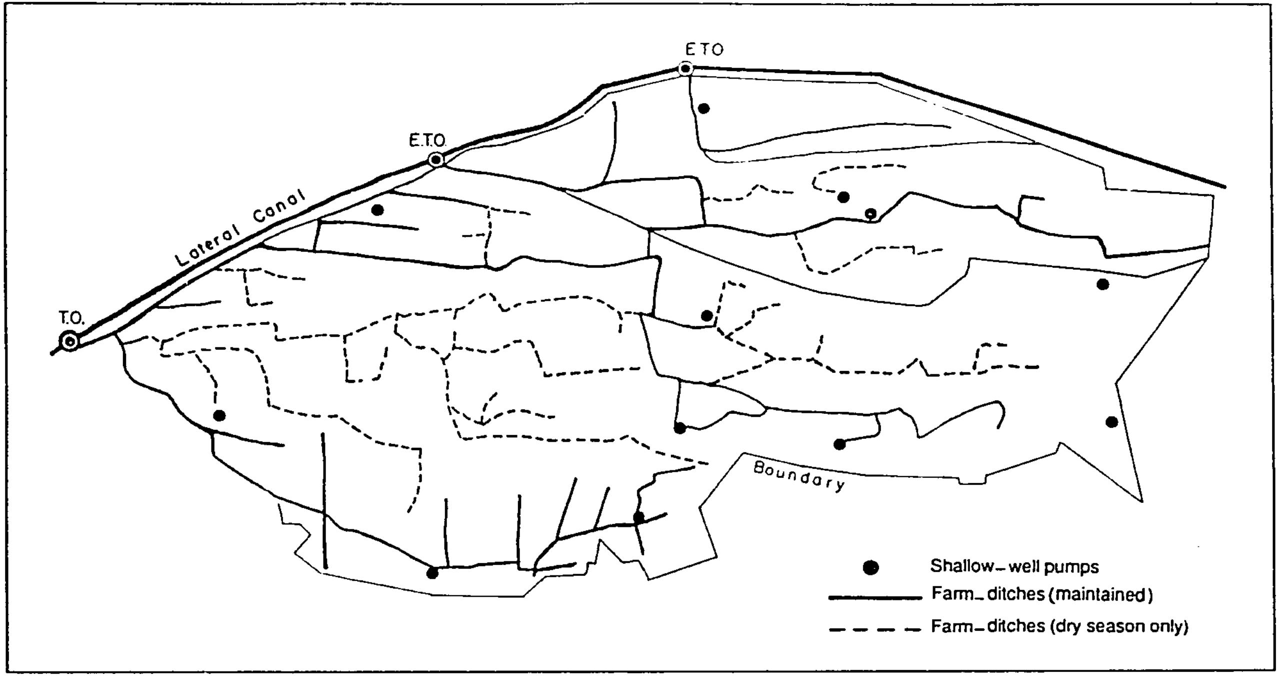


Source: Miranda 1989.

The main feature of these irrigation application practices is the retention of the rice dikes or bunds. This facilitates the shifting of cultivation practices to rice in the wet season. With this practice of retaining the rice dikes, no major landforming activities have to be undertaken either for the non-rice crops or for reverting to rice in the wet season.

Plot by plot irrigation and facilities for drainage of non-rice crops, in this case onion, necessitate the provision of additional internal farm ditches (Figure 7). These ditches are only made in the dry season and are removed once land preparation for rice crops in the wet season starts. With these ditches, the conveyance of irrigation water from the turnout or offtake is facilitated and this water is directed only to the specific plot where the onion or garlic crops are planted. For rice and tobacco, particularly at SFRIS, plot *to* plot irrigation is practiced by the farmers. For onion and garlic, plot *by* plot irrigation and farm ditches are used (Tabbal et al. 1990b).

Figure 7. Layout of a turnout service area served by an authorized turnout (T.O.) and an extra turnout (E.T.O.) at the Upper Talavera River Irrigation System (UTRIS), showing additional farm ditches used by farmers in the dry season.



Source: Tabbal et al. 1990a.

With these farm plot configurations and conveyance facilities, optimum densities of farm ditches and area served by a turnout were determined. For irrigation systems with average small farm holdings (less than 0.3 ha) and average large farm holdings (1-2 ha), the average farm ditch density was around 100 meters per ha, but it can be as much as 225 meters per ha too. While the optimum size of a turnout service area for small farm holdings should be about 3 ha, for large farm holdings it should be about 19 ha (Table 5).

Table 5. Average farm ditch length, turnout service area and farm ditch density, at LVRIS and UTRIS.

System	Orientation*	Farm ditch length (m)	Turnout service area (ha)	Farm ditch density(m/ha)
LVRIS	Parallel	336	3.23	104
	Perpendicular	245	2.21	111
	Average	291	2.72	107
UTRIS	Parallel	2,012	17.2	117
	Perpendicular	1,848	19.6	94
	Average	1,924	18.5	104

*Main farm ditch orientation was found to be a significant classification in relation to the physical factors affecting farm ditch length (Final Report: On-Farm Facilities Study, IRRI/NIA 1984). By "parallel" is meant the orientation of the main farm ditch parallel to the source of water or the canal supplying the turnout service area and by "perpendicular" is meant the orientation of the main farm ditch perpendicular to the source of water or the canal.

Source: IIMI 1990.

The main implication of this finding is that the acceptable number of farmers sharing irrigation water from a turnout in the dry season, when water is limited and unreliable, will be about 10. With this number of farmers, conflict in water sharing is minimal and distribution is effectively carried out, particularly when rotation is practiced among farmers.

34

WATER USE

Most non-rice crops except cotton used significantly smaller amounts of water than rice crops (Table 6). However, the literature only indicated the farm-level gross amount applied, mostly derived from experimental plots. With this information, assumptions of water savings are made for cultivating non-rice crops instead of rice crops. This is the "static" perception of rice versus non-rice water use (Moya 1990). However, empirical measurements from UTRIS indicated that water use for onion was not much different from that of rice (Table 7). In some cases, the amount of gross water delivered to onion was more than that for rice.

This discrepancy between published values and amounts measured in these studies can be explained by the environments and methods of application under which these values for rice and non-rice crops were obtained. While continuous and low-volume flow rates of irrigation water characterize the irrigation of rice, intermittent and large-volume flow rates characterize the irrigation of non-rice (Tables 7 and 8).

Table 6. Water use, critical growth stage, crop duration and moisture sensitivity characteristics of rice crops and selected non-rice crops in the Philippines.

Crop	Total water applied (mm)	Average growing period (days)	Critical period	Remarks
Rice*	800-1,000	110-120	Reproductive stage	Sensitivity to moisture stress and submergence > 3 days
Corn	600	90-120	Tasseling to grain formation	Sensitive to very shallow water table
Bean	300-500	60-90	Flowering and pod development	Vegetative period is sensitive to excess moisture
Cotton	700-1,300	150-180	Flowering period	Oversupply of water retards fruiting and branching and delays maturity. Sensitivity to excess moisture at any stage > 4 days
Garlic	360-400	90-120	-------	Requires moderately moist soil
Onion	350-550	90-100	Period of root bulb formation	-------
Peanut	580	140-160	Peak of flowering and early pod formation	-------

**Source:* De Datta 1981, for rice; PCARRD 1982, for other crops.

Table 7. Total water delivered, usage and irrigation interval for rice and non-rice crops at plot, turnout and lateral levels, UTRIS, dry season.

	Rice (mm)	Onion (mm)
Plot (Farm) level		
(Moya 1990)	1,666 - 2,763	498 - 948
(Tabbal et.al.,1990a/1990b)[1]	1,309	442 - 834
Turnout level[2]	na	1,323
Lateral level[3]	3,239	2,324
Irrigation interval (days)	4 - 7	9 - 19 days
Irrigation delivery efficiency[4]	40 - 85 %	19 - 41 %

[1]The total water delivered includes rainfall and irrigation water for land preparation for rice (Tabbal et al. 1990a), and the averages for mulched and unmulched onion plots are 442 mm and 834 mm, respectively (Tabbal et al. 1990b).
[2]Average of total water delivered at the turnout level for mulched onion (Tabbal et al. 1990a).
[3]Lateral A irrigated 72 ha of purely rice crops while Lateral B irrigated 134 ha of non-rice crops, mainly onion (IIMI 1990).
[4]Ratio in percent of farm level to the lateral level amounts of total water delivered. The range of efficiencies was based on minimum amounts of farm level water use.

Table 8. Average irrigation water supply delivery rates at the laterals serving purely rice, non-rice and mixed crops at UTRIS and SFRIS, dry season, 1988/1989 (l/s/ha).

System	Land preparation period	Crop growth period	Seasonal average
UTRIS			
Rice	3.35[a]	1.78[b]	2.28[b]
Onion	3.34[a]	2.18[a]	2.35[a]
SFRIS			
Rice	1.15[b]	0.98[c]	1.03[c]
Tobacco	2.23[a]	2.20[a]	2.21[a]
Rice-Tobacco	2.06[a]	1.52[b]	1.66[b]

Note:

In each column, the average values followed by the same letter are statistically not significantly different at 5 percent probability level.

Source: Moya 1990.

FLOW RATES FOR RICE AND NON-RICE CROPS

There are more losses associated with the irrigation of non-rice crops than with the irrigation of rice crops. These losses are attributed to the process of generating large-volume flow rates with inadequate control facilities that characterize most of the run-of-the-river systems in the Philippines. Although the irrigation systems were designed for rice irrigation even in the dry season, irrigation of non-rice crops was made possible using water control facilities meant for irrigating rice.

Farmers were responsive to this change in irrigation procedures as illustrated by the use of farm ditches and the retention of rice dikes. In some cases, farmers interfered with the control of the main and secondary canals by obstructing the flow for building up enough head by placing tree trunks, planks and other materials. With improperly maintained canal embankments and the absence of turnout gates, leakages are inevitable during the impounding period.

To generate large-volume flow rates, farmers at SFRIS had to impound 612 m^3 to push about 80 l/s of irrigation water in a turnout to irrigate tobacco while to generate small-volume flow rates, they had to impound only 363 m^3 to push 30 l/s of irrigation water in a turnout to irrigate rice (Moya 1990). An average of 40 cm of head was needed to arrive at an acceptable operating head to irrigate non-rice crops.

The main reason for generating intermittent and large-volume flow rates in irrigating non-rice crops is to provide the optimum contact time (infiltration opportunity time). Excessive exposure to moisture, which is the result of continuous and low-volume flow rates, is detrimental to non-rice crops.

With low volumetric flow rates in the dry season for most of the secondary canals in the Luzon systems, farmers were observed to wait and build enough head to irrigate their tobacco and onion crops. At SFRIS, farmers queued up to get their share of water for irrigating the tobacco fields (Moya 1990). The sequential rotation of water distribution even within each turnout was observed at both UTRIS and SFRIS.

This is consistent with the results of the study on optimum area served by a turnout for irrigating non-rice crops, limiting the number of farmers sharing and distributing water among themselves to an average of about 10 farmers per turnout.

In the land preparation stage, the irrigation water delivery rates are not much different between rice and non-rice. The difference in rates is, however, significantly pronounced during the crop growth stage (Table 6). In the dry season, when water becomes scarce, rotational irrigation is usually resorted to by the NIA field staff. Among the crops planted, rice requires a shorter irrigation interval (4-7 days) in this rotation than the non-rice crops (9-19 days) (Table 6). The main reason for this is the sensitivity of rice crops to moisture deficit whereby rice yields are significantly affected without three days of standing water (Wickham and Sen 1978), while non-rice crops, particularly deep-rooted crops, can tolerate up to 19 such days between irrigations.

If losses are to be reduced in the irrigation of non-rice crops, particularly in generating large-volume flow rates, both structural and organizational improvements have to be made. Control facilities such as functional turnout and cross-regulator gates, well-maintained canals, and effective water allocation and distribution procedures by the NIA field staff must be in place to minimize the conveyance and other losses associated with irrigating non-rice crops in these systems.

Based on the data gathered so far, it is not clear nor totally convincing that non-rice crops indeed use less water than rice. However, this argument can be viewed another way. If rice was the only crop planted, there is no doubt that a much smaller area would be productively irrigated in the dry season (Table 6). The current practice by farmers in the Luzon systems is planting mixed crops, both rice and non-rice, resulting in a larger irrigated area.

The rice crops will not productively survive in a rotation longer than seven days but non-rice crops will do so (Table 6). This is another indication that a larger area with a smaller supply of lesser irrigation water can be planted to non-rice crops.

The planting of corn adjacent to rice is relevant to the observation that a mixture of crops indeed increases the area planted and irrigated. This practice has been successfully carried out particularly at BARIS of the Mindanao system. About 5 percent of the total area in the dry season at BARIS is planted to corn without additional irrigation water supply (IIMI 1990). However, the corn crops are not directly irrigated from the canals but instead subsist on rainfall and on seepage water from adjacent rice fields.

The corn crops are planted on a higher elevation but adjacent to irrigated rice fields. Observations indicate that the water table below the corn fields can rise to as much as 40 cm below the surface when the adjacent rice fields are irrigated. The danger of excess moisture or waterlogging was not observed due to the coarse texture of the soil and also due to the non-stagnation of the shallow water table. With this practice of irrigation by seepage, the farmers are not billed by NIA for irrigation service fees as long as they pay the fees billed for the rice crop.

For a medium or less-coarsely textured soil, planting corn adjacent to rice fields will necessitate the provision of farm ditches. These ditches will be needed to act as interceptor drains to prevent waterlogging in the corn fields (Alagcan and Bhuiyan 1990). The study indicated that the plot with a depth of 50-cm interceptor drainage ditch resulted in the highest corn yield of 7.3 t/ha.

Farmers are adept in cultivating irrigated non-rice crops in the dry season. Cultivating non-rice crops without removing or retaining the rice dikes or bunds for rice culture in the wet season, has led to soil and water conservation. The use of farm ditches in irrigating plot to plot has also effectively accommodated non-rice crop irrigation in the dry season. This practice has led to the increase in farm ditch density.

Although non-rice crops require less water, they require higher flow rates than for rice. The generation of this higher flow rate with a limited water supply and inadequate control facilities, has led to inevitable conveyance and application losses in irrigating non-rice crops. This has subsequently resulted in the misleading perception that non-rice crops demand more water than rice. Furthermore, it has been observed that when a large volume of water is impounded to start-up high-volume flow rates, farmers queue up to get their share of water from the process of sequential rotation within a turnout. This explains why the optimum number of farmers served by a turnout that can effectively share and minimize conflict in water distribution is 10 on the average.

In summary, there is no direct empirical evidence that non-rice crops significantly demand less water than rice crops. However, the data show that with limited water supply in the dry season, a larger area can be productively irrigated if a mixture of rice and non-rice crops is planted instead of only rice. This was made possible with the implementation of rotational irrigation. Rotations can be practiced among portions of the primary canals, among secondary canals, or among the individual plots within the turnout; they can also be practiced yearly as is done at BARIS.

CHAPTER 4

Irrigation System Management

THE PLANS AND procedures used for irrigating non-rice crops in the dry season were basically the same as those for rice crops with slight modifications. With mixed cropping, the only changes made were in the duration of turns for sections of the canals where mostly non-rice crops were grown.

Coupled with inadequate irrigation facilities and inept field staff, it is not surprising to note that the procedures for irrigation of rice are followed for non-rice crops. Rotations among sections of the main canal and secondary canals are carried out as a response to the limited water supply. These rotational procedures are most successful in systems where Irrigators' Associations have been actively involved in the planning and implementation of the rotational schedules.

IRRIGATION FACILITIES

The irrigation and control facilities provided to the systems were designed primarily for rice irrigation. Even ARIP, which was supposedly designed to effectively irrigate non-rice crops, was found to have inadequate facilities in terms of number of turnouts per service area (Table 9). The optimum turnout service area for non-rice crops was found to be less than 20 ha for systems with 1- to 2-ha farm holdings. This was considered optimum since it has been used effectively by the farmers for more than three decades at UTRIS.

41 2

Table 9. Selected structural characteristics of five irrigation system sites.

Items	ARIP	BARIS	LVRIS	UTRIS	BP#2
A. *General description*					
Dam type	Barrage	Ogee	Ogee	Ogee	Surface pump
Service area (ha)	7,311	3,160	2,377	4,650	507
Year constructed	1988	1973	1932	1965	1977
Year rehabilitated[1]	–	1980	1987	1974	1987
B. *Turnouts (T.O.)*					
Total number	193	198	418	255	189
With control gates, etc.[2]	187	25	412	93	185
Average density (ha/T.O.)	38	16	6	15	3
FR, %[3]	97	13	99	36	98
C. *Lateral headgate*					
Total number	13	11	13	15	6
With control gates, etc.[1]	13	10	12	11	6
FR, %[3]	100	91	92	73	100
D. *Canals*[4]					
Total length (km)	83	45	73	40	25
Lined	83	13	3	1	25
FR, %[3]	100	29	5	3	100

[1]BARIS was planned to start rehabilitation in 1990. ARIP was operational in 1988. From 1977 to 1987, rehabilitation in LVRIS and BP#2 was undertaken under the National Irrigation Systems Improvement Program (NISIP) while in 1987, Irrigation Operation Support Project (IOSP) started concentrating on minor repairs and the formation of Irrigators' Associations (IAs) at LVRIS. Rehabilitation of UTRIS was undertaken under the Upper Pampanga River Project (UPRP) from 1969 to 1974, but is expected to be rehabilitated again under the International Bank for Reconstruction and Development (World Bank)-assisted IOSP in 1991.

[2]Turnouts and headgates with complete accessories such as gates and headwalls for effective diversion and control of flow.

[3]Facilities Ratio or FR, is the ratio of turnouts or headgate with complete accessories to the total number of turnouts or headgates, and also for canals with lining to the total length of canal, in percent (e.g., ARIP {T.O. w/ gates [187]/[193] total number of T.O.} x 100 = 97%)

[4]At ARIP and BP#2, primary and secondary lateral canals are completely lined. At LVRIS, BARIS and UTRIS, only portions of the system are lined. ARIP and BARIS were ADB-assisted and the others IBRD-assisted.

Source: IIMI 1990.

The degree of inadequacy in irrigation facilities can be gleaned from the selected structural characteristics for each of the systems (Table 9). Both BARIS and UTRIS were planned for rehabilitation in the coming years but they have the least facilities among the study locations. With the exacting demands of non-rice crops for intermittent and large-volume flow rates, it is noteworthy that the system can still cope with this state of structural facilities despite the consequent inefficiencies leading to losses in irrigation water.

The job of making effective use of these facilities is nominally the responsibility of the NIA field staff. However, with the active involvement of the farmers, allocation, distribution and maintenance activities in the systems are facilitated through the Irrigators' Associations (IAs) (Table 10).

STAFFING DENSITY

The nominal densities of the field staff in each system also indicate the degree of IA participation in the management of the system. BARIS where the density of the field staff is the lowest has the most active IAs among the systems (Tables 10 and 11). In this system, the federated IAs participate in the yearly and seasonal allocation and distribution of irrigation water. A meeting between the IAs and the NIA staff is held before the start of each cropping season to discuss plans for the allocation of water. At this meeting an agreed-upon allocation plan is adopted. When water supply becomes scarce within the season, a separate meeting with farmers is called to plan and agree upon a rotational schedule in the implementation of which farmers are involved.

Table 10. NIA field staff density and status of Irrigators' Associations (IAs) at the five system sites.

Site	ARIP	BARIS	LVRIS	UTRIS	BP#2[1]
NIA					
Irrigation Superintendent (IS)[2]	1	1	1	1	0
Assistant Irrigation Superintendent (AIS)	1	1	1	0	0
Watermasters (WM)	6	3	4	5	1
Ditchtender	6	3	16	23	1
Gatekeeper (GK)[3]	3	1	0	3	0
IAs					
Number of IAs	15	9	3	6	1
Number of IGs[4]	196	198	38	255	0
Number of IA members	na	1,300	na	2,037	500
Number of IAs with NIA contract[5]	15	1	2	3	1

[1]BP#2 is entirely operated and maintained by BP#2 IA in a two-year contract with NIA subject to renegotiation thereafter. Only three NIA staff are assigned to assist IA - the Watermaster, Pump Operator and Irrigators' Community Organizer (ICO). The only responsibility of IA to NIA is the payment of bills for electricity used in operating the pumps.

[2]ARIP and BARIS are under one Irrigation Superintendent (IS) who is assisted by an Assistant Irrigation Superintendent (AIS) for each system. LVRIS and BP#2 are two systems of the Ilocos Norte Irrigation Service (INIS) which is under one IS. LVRIS is directly managed by four Watermasters. UTRIS is a system under District I of the Upper Pampanga River Integrated Irrigation System (UPRIIS). UTRIS is managed by a Zone Engineer who is equivalent to an IS.

[3]The assigned Gatekeepers are tasked to oversee the 24-hour operation of ARIP and UTRIS dams.

[4]At ARIP, BARIS and UTRIS, an Irrigators' Group (IG) is composed of farmers served by one turnout while at LVRIS, an IG is composed of the farmers in the district served by several turnouts.

[5]Refers to IAs under contract with NIA for operation and maintenance and authorized to collect irrigation service fees.

Source: IIMI 1990.

Table 11. Nominal NIA staffing density on area irrigated, gates and canal length maintained for selected irrigation systems.

System	Total number of field staff[1]	Area[2] (ha/staff)	Gates[3] (no./staff)	Canal length[4] (km/staff)
ARIP	15	487	14	5.5
BARIS	7	451	30	6.4
LVRIS	20	119	22	3.6
UTRIS	31	126	9	1.3
Average	18	296	19	4.2

[1]This includes only the Watermasters, Ditchtenders and Gatekeepers. Ditchtenders also act as Gatekeepers in some systems.

[2]The nominal command or service area is used in this estimate.

[3]The total number of gates includes turnouts and lateral headgates but not the diversion dam gates.

[4]The total canal length includes only the main or primary and secondary lateral canals.

Annual rotation is the practice at BARIS. With the limited water supply in the dry season, certain portions of the system take turns in not being assured of irrigation water for rice. However, planting of corn is encouraged in these sections. Irrigation is not guaranteed but occasional "flushing" is committed by the NIA staff, provided the irrigation of rice would not be jeopardized. The priority was still the irrigation of rice. Approximately 5-10 percent of the dry-season area is planted to corn. In the dry season of 1987/1988, due to a successful staggering of irrigation schedules adhered to by the majority of farmers, about 160 ha of corn were planted within the system (Table 12).

Table 12. Summary of relative water supply, average yield of rice and non-rice crops, and areas irrigated at selected systems, dry seasons, 1986-1989.

		LVRIS	BP#2	UTRIS	ARIP	BARIS
1986/1987						
Relative water supply[1]	System	1.0	3.5	na	na	1.5
	Head	1.3	na	na	na	2.0
	Middle	1.1	na	na	na	na
	Tail	0.9	na	na	na	1.2
Area, (ha)	Rice	924	107	611	3,000	1,730
	Non-rice	628	71	159	0	60
	Total	1,552	178	770	3,000	1,790
Yield, (t/ha)	Rice	5.01	3.37	3.77	4.40	3.80
	Non-rice[2]	1.70	2.42	10.66	na	4.30
1987/1988						
Relative water supply	System	1.54	1.4	1.52	2.6	1.3
	Head	1.5	na	1.78	2.7	1.6
	Middle	1.6	na	na	3.1	na
	Tail	1.8	na	1.39	2.1	1.0
Area, (ha)	Rice	970	101	620	3,038	1,750
	Non-rice	643	71	596	27	160
	Total	1,613	172	1,216	3,065	1,910
Yield, (t/ha)	Rice	3.03	3.37	2.51	4.02	3.87
	Non-rice[2]	0.75	2.42	4.30	3.71	4.00
1988/1989						
Relative water supply	System	1.37	1.4	2.38	3.0	1.3
	Head	1.62	na	2.43	3.3	1.0
	Middle	1.3	na	na	3.4	na
	Tail	1.31	na	1.78	2.3	1.5
Area, (ha)	Rice	994	187	490	4,197	1,794
	Non-rice	595	61	762	29	50
	Total	1,589	248	1,252	4,226	1,794
Yield, (t/ha)	Rice	3.00	3.90	4.60	3.30	3.30
	Non-rice[2]	1.96	3.20	7.40	4.30	3.90

[1]For LVRIS and BP#2, values were based on midland late season values. For UTRIS and ARIP, flow measurements started during the 1987 wet season. Relative water

supply : RWS = (AIF + RF)/IDR
AIF = Actual irrigation flow
RF = Rainfall
IDR = Estimated irrigation diversion requirement
[2]Hybrid corn planted at ARIP and BARIS was not irrigated by NIA.
Non-rice crops (ARIP and BARIS - hybrid corn; LVRIS and BP#2 - garlic; UTRIS - onion).

The IAs at ARIP were recently organized and contracts for canal maintenance and collection of irrigation service fee were awarded. Similar procedures in terms of water allocation and distribution were carried out in this system. However, despite field demonstrations and campaigns to encourage farmers to plant non-rice crops in the dry season, only a very few farmers were found receptive to this encouragement; in fact, the total area of non-rice crops planted in the dry season was 29 ha (Table 12).

Without the IAs actively participating in the management of the system, it is doubtful if optimum use of dry-season irrigation water supply is feasible. Given the density of field staff to operate about 19 gates on the average and oversee water distribution covering around 4 km of canals, shortcomings in managing the systems are to be expected.

With the limited available resources for operation and maintenance, NIA was not able to effectively cope with the day-to-day demands of managing the irrigation system, especially when the water supply became scarce in the dry season. The active participation of the IAs becomes imperative not only in the collection of irrigation fees but significantly more so in the allocation and distribution of water and the maintenance of the system.

FIELD-TESTING OF IRRIGATION MANAGEMENT GUIDELINES

The potential of improving dry-season crop diversification was considered only for the Luzon systems, LVRIS and UTRIS. However, lessons learned and information generated from BARIS and ARIP were made use of in arriving at the procedures for improving the management of systems for diversified cropping in the dry season.

41

A set of procedures was developed using the results of the studies at all of the sites (Valera et al. 1989b). However, these procedures were only field-tested with the implementation of the IIMI-IRRI Collaborative Project on Irrigation Management for Rice-Based Farming Systems (Maglinao et al. 1990). The effectiveness of these procedures was field-tested at LVRIS and UTRIS. These procedures are summarized in Table 13.

The results of these procedures indicated improvement in the distribution of irrigation water during the 1989/1990 dry season at LVRIS but more pronounced at UTRIS (tables 14 and 15). The impact of the procedures significantly increased the area irrigated at UTRIS in the 1989/1990 dry season. By reactivating some IAs and with regular meetings held between IAs and the NIA staff, cooperation of the farmers was obtained. In these meetings, allocation and scheduling of water deliveries were discussed. The most feasible way of increasing the availability of irrigation water at UTRIS was to advance the planting dates in the wet and dry seasons. This, in effect, will take advantage of the rainfall and afford a larger area to be irrigated in the dry season (Cablayan et al. 1990a).

Table 13. Summary of existing NIA procedures and recommended guidelines to improve irrigation management.

Activity	General procedures		Field-tested procedures	
	Existing	Recommended	Existing	Recommended
PLANNING (steps) A. *Estimation of available water supply*				
– Dependable rainfall	5-year moving average.	Incomplete Gamma Distribution analysis. Augment existing data and reanalyze annually.	Weekly rainfall mean based on previous 5-year data. When instrument for rainfall measurement breaks down, no data are added and the database is not updated and the plan for the previous year is adopted.	Weekly dependable rainfall values to be adjusted annually as data are added to previous records.
– Stream flow (river discharge)	5-year moving average.	Log-Normal/Log-Pearson Distribution Analysis. Augment existing data and reanalyze annually.	Streamflow observations not being done (stopped). Database on outdated data; hence, annual program is unchanging and personnel regard planning as just copying previous plans for submission as required.	Weekly dependable river flow values to be adjusted annually as data are added to previous records.
– Other sources	Existing drainage reuse dams, and private shallow well pumps.	Identify other points where reuse dams could be constructed to fully utilize all possible water sources.		

(Continued)

Table 13 (Continued)

Activity	General procedures		Field-tested procedures	
	Existing	Recommended	Existing	Recommended
B. Estimation of irrigation demand				
– crop water duty	Based on rice.	Based on particular crop grown using crop coefficients and panevaporation data. Existing data to be verified during actual system operation.	Outdated data result in unequal distribution of water in the day-to-day operation of the system due to incorrect assessment of water needs.	Verified data for use in planning and actual system operation.
– soil demand	Existing data but are they still in use or already lost in records?	Based on agro-hydrological soil characterization.	Data may be outdated already, resulting in uneven distribution of water in daily system operation due to incorrect assessment of water needs.	Verified data per area and crop for use in planning and actual system operation.
– efficiencies, distribution losses, application losses, system efficiencies.	Existing data but are they still in use or already lost in records?	Verification of data based on soil types, farmers' practices, crops grown and existing structures and other irrigation facilities.	Data may be outdated already, resulting in the same situation as above.	Verified data for use in planning and actual daily operation.

(Continued)

Table 13 (Continued)

Activity	General procedures		Field-tested procedures	
	Existing	Recommended	Existing	Recommended
C. *Involvement of Irrigators' Associations*				
– planning	Minimal involvement or none.	Active farmers' involvement in decisions on areas to be served, crops to be grown, operation dates and irrigation methods to be used.	Farmers not following plans resulting in inefficient performance due to disruption of planned activities; thus no semblance of farmers' discipline in diverting water, especially when there is no immediate water shortage.	Plans that are acceptable and followed by farmers.
– water distribution	Minimal involvement or none.	Active involvement in planning implementation and feedback mechanism for evaluation of water distribution strategies.	It is only during periods of critical water supply where strict supervision is implemented that efficient operation can be achieved.	Operation strategies responsive to farmer needs and system limitation, efficient use of available water resources.

Table 14. Estimated irrigation diversion requirement (IDR), actual irrigation flow (AIF), water sharing and mean weekly relative water supply (RWS), LVRIS, dry seasons, 1987-1989.

Division	IDR (mm/wk)	AIF (mm/wk)	Water sharing (%)	RWS
Dry season 1987/1988				
System	62	148ab	100	1.54ab
Division 1	87	187a	44	1.58ab
Division 2	60	100b	8	1.43a
Division 3	38	132ab	8	2.27b
Division 4	45	83b	23	1.67ab
Dry season 1988/1989				
System	78	156b	100	1.37ab
Division 1	85	267a	55	1.96b
Division 2	78	107ab	14	1.28ab
Division 3	62	61c	8	1.22a
Division 4	63	89bc	22	1.41ab
Dry season 1989/1990				
System	60	190ab	100	1.67ab
Division 1	81	238a	45	1.96ab
Division 2	55	195ab	34	2.27a
Division 3	54	93c	4	1.20c
Division 4	62	190ab	17	1.67ab

Notes: Means in the same column followed by the same letters are not significantly different at 5-percent level of significance. mm = millimeters; wk = week
Water sharing is the percentage of the total volume of irrigation water delivered to the different divisions of the system.

$$RWS = \frac{AIF + Rainfall}{IDR}$$

Source: Cablayan et al. 1990a.

Table 15. Estimated irrigation diversion requirement (IDR), actual irrigation flow (AIF), mean weekly relative water supply (RWS), UTRIS, Nueva Ecija, the Philippines, dry seasons, 1987-1989.

Division	IDR (mm/wk)	AIF (mm/wk)	Water sharing (%)	RWS
Dry season 1987/1988				
System	85	144^{a}	100	1.52^{ab}
Head	82	153^{a}	77	1.78^{b}
Tail	91	132^{a}	23	1.39^{a}
Dry season 1988/1989				
System	70	219^{a}	100	2.38^{a}
Head	63	204^{a}	49	2.43^{a}
Tail	86	346^{a}	51	1.78^{a}
Dry season 1989/1990				
System	79	279^{a}	100	1.67^{a}
Head	75	223^{a}	54	2.00^{a}
Tail	86	173^{a}	44	1.37^{a}

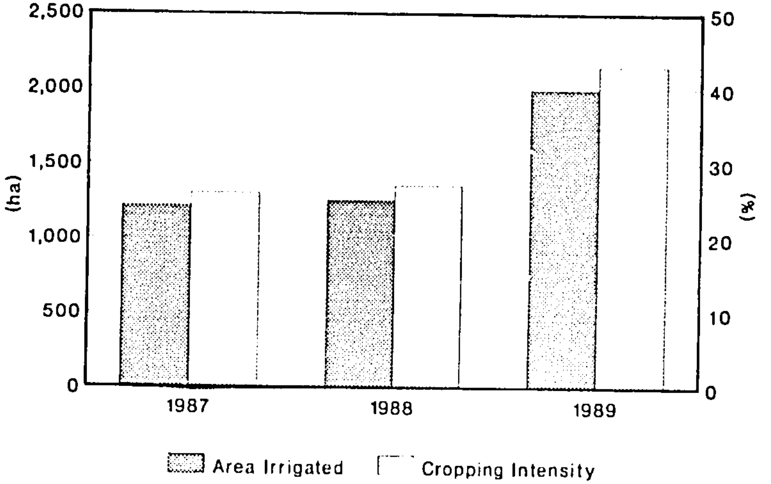
Notes: Means in the same column followed by the same letter are not significantly different at 5-percent level of significance.
Water sharing is the percentage of the total volume of irrigation water delivered to upstream and downstream portions of the system.

$$RWS = \frac{AIF + Rainfall.}{IDR}$$

Source: Cablayan et al. 1990a.

With about 70 percent of the farmers adhering to the new schedule in planting, a larger area was irrigated in the dry season. This effectively increased the cropping intensity at UTRIS by 15 percent in the dry season and also for the whole cropping year (Figure 8 and Table 4).

Figure 8. Area and cropping intensity, UTRIS, dry seasons, 1987-1989.



The observed improvement in the allocation and distribution of water at UTRIS was accomplished without significant changes in the control structures in the system. This limited the impact of the improvement brought about by the changes in the procedures implemented.

Notwithstanding the significant results obtained, improvement in the rotational scheduling of irrigation water during periods of limited supply have to be seriously considered. The recommendation for further improvement requires careful assessment of allocation time. This was particularly critical for laterals serving non-rice crops wherein additional time for building up or generating large volume flow rates have to be considered in the rotational schedule. For rice areas, this aspect will not be as critical. With limited quantities or low flows, especially from the middle toward the end of the dry season, additional time is required for irrigating non-rice crops.

This observation is consistent with the concept of "critical" flow (Moya 1990). The critical flow in this case is the minimum flow rate below which irrigation of non-rice crops will be infeasible. When the flow rate is low, irrigation of non-rice crops will be exposed to excessive moisture before the moisture requirements of the entire field are met. In other words, the optimum contact time between the soil and water will be exceeded if the irrigation water supply is below the critical flow. With higher flow rates demanded by non-rice crops, critical demand flow rates were estimated (Table 16).

Table 16. Estimated average and critical farmer water demand flow rates for different crops at UTRIS and SFRIS; dry season, 1988/1989 (m^3/ha/hour).

Crop	SFRIS		UTRIS	
	Average	Critical	Average	Critical
Rice				
Land preparation	610	300	637	332
Crop growth	515	347	629	338
Nonrice crops (Crop growth)				
Corn			758	561
Onion			1,008	370
Tobacco	1,232	332		
Cotton (pump)	492	479		
Tobacco (pump)	560	501		

Source: Moya 1990.

CHAPTER 5

Reliability and Distribution of Irrigation Water Supply

ONE OF THE primary reasons for farmers to plant a dry-season crop is the reliability of irrigation water supply. Despite the lesser amount of water demanded by non-rice crops, the reliability of irrigation water supply is still a major consideration in the preference for diversification. The major advantage of irrigated areas over rain-fed areas is the reliability of irrigation water supply compared to rainfall. Even in the Mindanao systems, where rainfall is also available in the dry season, reliability is not taken for granted.

Reliability has both physical and institutional dimensions. The availability of water from the river and the managerial capability of the NIA field staff for timely delivery of irrigation water to the canals based on farmers' demands are the major components of these dimensions. With the stochastic nature of river flows, it is difficult to incorporate even the physical aspect of reliability as an accurate indicator of reliability. Thus, measures of reliability are not readily available.

One measure obtained is based on the estimated proportion of time, matching the supply and demand for irrigation water (Moya 1990). In this estimation, assuming an 8-hour water delivery by the NIA staff and assuming farmers are able to irrigate, rice crops and mixed rice - non-rice crops are less reliably irrigated than only non-rice crops at both SFRIS and UTRIS (Table 17). In this case, continuous irrigation is more reliable than rotational irrigation. This result is consistent with the observed behavior of farmers during rotation when some farmers take water out of turn or beyond their scheduled time for irrigation. It was observed that the NIA field staff are partial toward irrigating non-rice crops as indicated by this estimate. One reason adduced for this observation was that farmers have influenced the NIA field staff for this partiality for irrigating non-rice crops, since these are the same farmers who diversify crops every dry season.

Table 17. Reliability (%) of water supplies at different stages of farming activities and method of water control for rice, onion, tobacco and mixed crops, at different laterals at UTRIS and SFRIS, the Philippines; dry season, 1988/1989 (assuming 8-hour water delivery).

Utilization and control levels	Stage of farming activities			Water distribution method	
	Land preparation	Crop growth	Season	Continuous	Rotation
UTRIS					
Only rice	98.0	22.6	50.7	75.3	8.2
Only onion	100.0	64.8	79.4	86.4	62.2
SFRIS (MCF subsystem)					
Only tobacco	34.0	27.7	29.9	29.0	31.5
Mixed rice-tobacco	73.9	21.3	37.0	31.5	50.0
SFRIS (MCJ subsystem)					
Mixed rice-tobacco	78.1	50.5	56.7	56.7	
Only rice	35.9	0.0	9.5	9.5	

Notes:
MCF = Main canal F
MCJ = Main canal J

Source: Moya 1990.

Another observation made with regard to the intensity of management of the NIA field staff in terms of hours observed in the field for irrigating rice and non-rice, verifies this contention. At UTRIS, the Ditchtender was observed to have spent 20 percent more time in managing irrigation water for onion than for rice. The Assistant Water Management Technician was observed to have spent 10 percent more time in managing the irrigation water for onion than for rice in the dry season of 1988/1989 (IIMI 1990).

Even for cultivating non-rice crops, farmers prefer a reliable supply, though less in volume, that lowers the risk of crop failure (Cablayan et al. 1990a). To further avoid or reduce the risk, an increasing number of farmers at the tail sections at UTRIS and SFRIS were observed to have invested or paid for shallow well pumps as augmentation supply for the irrigation water provided by NIA (Undan et al. 1990). This is just one of the risks that farmers have to deal with in crop production in the dry season.

The spatial inequity of irrigation water distribution was observed in all of the systems (Table 18). Both the farmers and the NIA field staff need to work together in attaining equitable distribution, particularly during periods of limited water supply. From the field-testing of the set of guidelines, it transpired that improvement in dry season irrigation system performance is feasible. The results at UTRIS and LVRIS were indicative of this improvement.

However, one can argue that the results are temporary due to the induced changes made during the implementation with IIMI intervention. More lasting improvements will result if control structures such as gates and turnouts are provided and canals are better maintained. To improve irrigation system performance structural improvements must be accompanied by institutionalization of procedures, which is easier said than done. It is toward this end that results of these studies or interventions can facilitate changes at NIA and among farmers with the dissemination of results through publications and with interactions with NIA on improving irrigation management.

In summary, to effectively manage irrigation systems in the dry season for irrigation of diversified crops, the following should be taken into account:

* improved operating rules appropriate to intermittent demand;
* very close collaboration of NIA with the Irrigators' Associations in developing and implementing seasonal plans and schedules;
* equitable and reliable irrigation water delivery;

* improved monitoring in the implementation of the schedules;
* a clear policy for dealing with any departures from the agreed-upon delivery schedules; and
* enhanced intensity of management and better motivated operations staff to achieve these requirements.

Table 18. Average seasonal relative water supply for the entire system and at different sections, cropping years, 1986-1989.

Season	LVRIS	BP#2	UTRIS	BARIS	ARIP
Dry 1986/1987					
System	1.0	3.5	–	1.5	–
Head	1.3				2.0
Tail	0.9				1.2
Wet 1987					
System	2.2	1.7	2.9	1.2	2.7
Head	2.6		4.0	1.5	3.0
Tail	1.4		1.8	0.9	1.3
Dry 1987/1988					
System	2.3	1.4	1.52	1.3	2.6
Head	2.28		1.78	1.6	2.7
Tail	2.10		1.39	1.0	2.1
Wet 1988					
System	2.7	1.2	3.3	1.5	2.9
Head	2.9		4.1	1.5	3.1
Tail	2.6		2.5	1.6	2.5
Dry 1988/1989					
System	1.37	1.4	2.38	1.3	3.0
Head	1.62		2.43	1.0	3.3
Tail	1.31		1.78	1.5	2.3

Note:
The four divisions at LVRIS were aggregated into head (Divisions 1 and 2) and tail (Divisions 3 and 4) sections.

Source: IIMI 1990.

CHAPTER 6

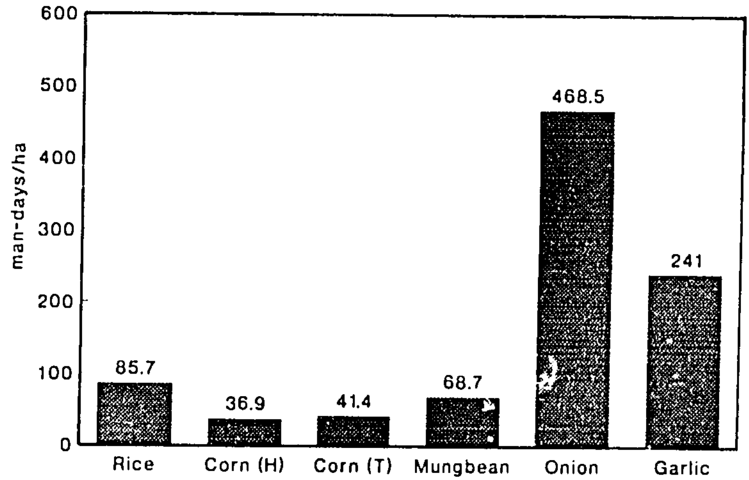
Economic Issues

THE FOREGOING DISCUSSIONS on the technical and, to some extent, institutional issues provided explanations for the effective practices and procedures for irrigation management of diversified cropping in rice-based systems. However, the complexity of crop diversification cannot be unraveled without considering the economic issues that significantly impinge on the farmers' decisions to diversify. These can be viewed sequentially as: markets (input and output) which determine price; profitability which is determined by price with production technology; and lastly, farmers' decisions to diversify which depend on the profitability of the crop selected (Kikuchi 1989). These are the factors included on the right-hand side of Figure 3.

INPUT AND OUTPUT MARKETS

Labor and land markets are major contributing factors in the input markets for diversified cropping in the Philippines. The cultivation of non-rice crops demands low to high labor intensities relative to rice crop production. The corn and mungbean crops demand less labor than rice while onion and garlic are three to five times more labor-intensive than rice (Figure 9). This is indicative of the availability of labor in most of the irrigated areas in the country. However, the amount of supervision time in cultivating non-rice crops is the more constraining aspect rather than the availability of labor (Pingali 1990).

Figure 9. Mean family labor for rice and non-rice crops, dry seasons, 1987-1989.



(H) Hybrid Corn
(T) Traditional Varieties of Corn

With the availability of rural labor and low development of mechanization, land is significantly the scarcer resource. The adoption of seasonal tenancy arrangements as exemplified at UTRIS to cope with labor and risk in dry-season crop diversification, indicates the flexibility of the land market (Pingali 1990). This practice is favorable to crop diversification considering the scarcity of land relative to labor.

Credit can be viewed as a facility to acquire inputs for production. In the case of non-rice crop production in irrigated areas, credit appears not to be a constraint. With an effective market mechanism for non-rice crops, such as in the cases of onion and garlic at UTRIS and LVRIS, respectively, low interest or cheap credit is provided by middlemen or traders (Kikuchi 1990). In return, the obligation of borrowers is to sell to the traders the equivalent amount of produce at the agreed-upon price, as payment for the loan.

Marketing is often cited as the "weakest" link in crop diversification. The marketing problem can be explained by the underdevelopment of marketing channels in which the price signals (indications of market price for non-rice crops) are not properly transmitted. Price risks dominate the production risks in non-rice crop production (Pingali 1990). The volatility of prices of non-rice crops attests to this assertion.

Except for the cereal crops, whose prices are to a large extent controlled by government pricing policies, prices of other non-rice crops are often variable. This is evident even in their average annual wholesale prices compared to rice and corn (Table 19 and Figure 10). Seasonal and even monthly fluctuations of prices in non-cereal, non-rice crops illustrate this volatility (Table 20 and Figure 11). This explains the assertion made regarding farmers' sensitivity to price risks when it comes to non-rice crop production.

Table 19. Annual average wholesale prices of rice and selected non-rice crops, adjusted to constant 1987 prices.

Year	Wholesale price (P/kg)				
	Rice	Corn	Mungbean	Onion	Garlic
1978	2.97	3.69	14.53	9.11	31.43
1979	2.95	3.37	12.78	9.95	40.46
1980	3.05	3.74	16.22	9.32	60.47
1981	3.05	3.75	16.40	10.33	81.62
1982	2.92	3.39	13.97	8.14	49.71
1983	2.96	3.44	14.38	16.55	44.16
1984	3.18	3.76	14.35	8.51	67.96
1985	3.39	3.73	14.50	9.58	57.14
1986	2.93	3.61	14.64	8.96	33.87
1987	3.07	3.65	13.63	8.02	28.78
1988	3.21	3.68	14.03	14.83	105.00
1989	3.29	3.55	13.07	9.07	89.90
Mean	3.08	3.61	14.37	10.20	57.54
Standard Deviation	0.154	0.143	1.07	2.68	24.49
C.V.	5.0	4.0	7.5	26.3	42.6

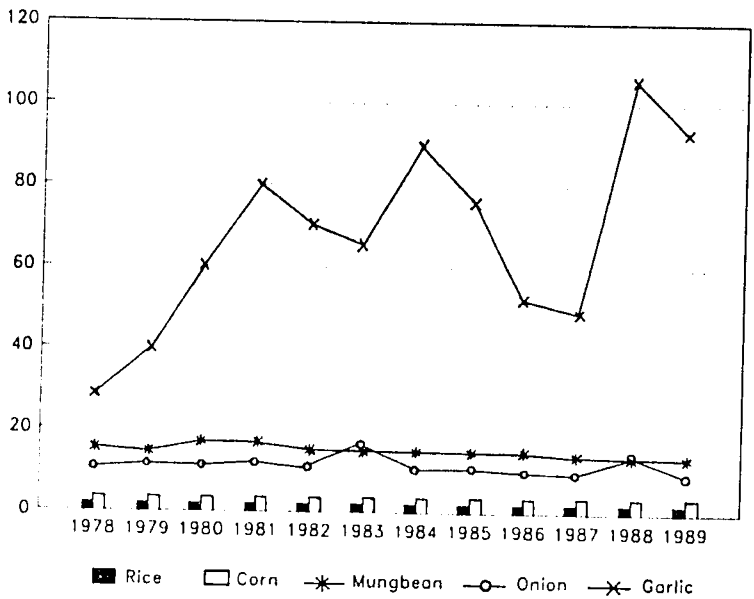
Notes:

P = Pesos

C.V. = Coefficient of Variation in percent.

Source: Bureau of Agricultural Statistics 1988.

Figure 10. Comparison of annual average wholesale prices of rice and non-rice crops (adjusted to 1987 prices).



64

Table 20. Monthly average farmgate prices of rice and selected non-rice crops, 1988-1989.

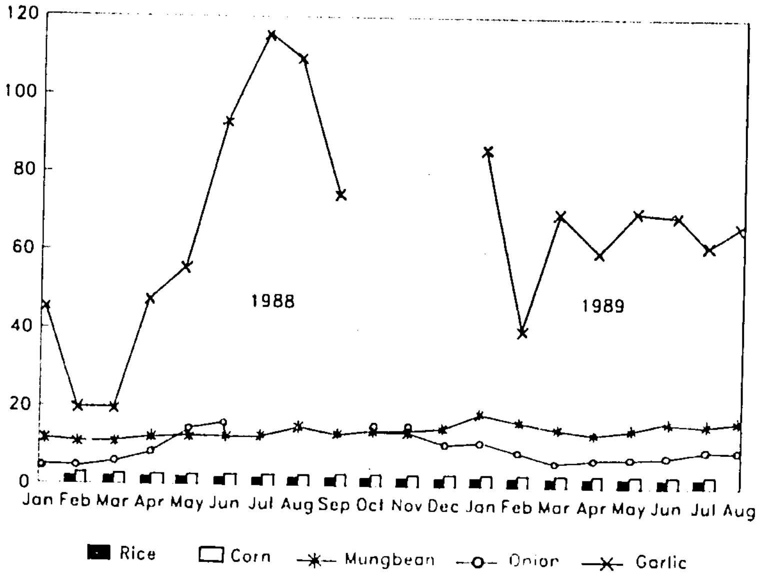
Year	Month	Average farmgate price (P/kg)				
		Rice	Corn	Mungbean	Onion	Garlic
1988	Jan	3.06	3.67	11.46	4.31	45.00
	Feb	3.29	3.53	10.70	3.79	19.67
	Mar	3.45	3.83	11.26	5.26	19.40
	Apr	3.40	4.25	11.53	7.33	46.69
	May	3.53	4.28	11.70	12.59	54.67
	Jun	3.58	4.13	11.57	13.88	92.25
	Jul	3.61	3.94	11.51	na	115.50
	Aug	3.74	3.92	14.13	na	110.00
	Sep	3.60	3.77	11.67	na	75.00
	Oct	3.30	3.72	13.47	13.83	na
	Nov	3.31	3.08	13.73	14.56	na
	Dec	3.45	3.97	15.30	10.44	na
1989	Jan	3.54	3.84	19.04	11.77	85.50
	Feb	3.63	3.90	16.49	7.89	39.50
	Mar	3.83	4.12	15.63	5.82	69.34
	Apr	4.03	4.38	13.24	6.48	60.22
	May	4.05	4.42	14.36	6.12	69.90
	Jun	4.14	4.39	16.83	6.15	69.59
	Jul	na	na	15.69	9.26	61.19
	Aug	na	na	17.80	8.86	68.49
Coefficient of Variation (%)		8.1	6.6	18.1	40.5	41.5

Note:

na - not available.

Source: Bureau of Agricultural Statistics 1988.

Figure 11. Comparison of monthly average farmgate prices of rice and non-rice crops, 1988-1989.



PROFITABILITY

The profitability of non-rice crops fluctuates in accordance with the prices of these crops, particularly garlic and onion, which have been consistently more profitable than rice (Table 21). Except for mungbean and to some extent for corn, production of non-rice crops has been more profitable than that of rice.

The price risks associated with the production of non-rice crops can also be associated with the level of production costs involved. Except for garlic, all other crops have proportionate production costs and net returns relative to rice (Table 21). With higher production costs of non-rice crops, it is not surprising that farmers are very sensitive to price risks.

66

Table 21. Production costs and net returns (P/ha) for rice and the ratio of average production costs and net returns of selected non-rice crops to rice, for Luzon and Mindanao systems, dry seasons, 1986-1988.

Years	Production costs				Net returns			
	1986/1987	1987/1988	1988/1989	Mean	1986/1987	1987/1988	1988/1989	Mean
A. Luzon systems								
Rice (P/ha)	4,659	4,653	6,526	5,279	6,270	5,714	8,044	6,676
Corn/rice	0.90	0.92	0.94	0.93	0.70	1.32	0.96	0.98
Mungbean/rice	0.61	0.41	0.40	0.46	0.71	0.88	0.47	0.66
Onion/rice	2.62	4.68	3.23	3.48	2.67	7.17	1.13	3.34
Garlic/rice	2.25	3.02	5.48	3.81	1.33	2.85	17.40	8.22
B. Mindanao system								
Rice (P/ha)	4,092	4,892	5,638	4,853	5,839	6,680	8,014	6,844
Corn/rice	0.70	0.79	0.83	0.78	1.34	0.64	1.32	1.10

Note:
P = Pesos
Source: IIMI 1990

Despite the relative profitability of corn produced in Mindanao, there appears to be a comparative advantage of producing corn in irrigated areas of Luzon. With the prohibitive transportation costs of shipping corn from Mindanao, feed millers in Cebu and Manila find it cheaper to purchase imported corn (Adriano and Cedillo 1990).

With lower production costs and with proximity to markets, corn produced in the irrigated parts of Luzon can be an alternative to rice in the dry season, provided high yields are maintained. A simulation exercise was carried out among selected irrigation systems. The systems in Mindanao had corn as the most viable alternative besides rice in the dry season (IIMI 1990). However, for LVRIS and UTRIS, several combinations of rice and non-rice crops were tried out.

The major assumptions made in the simulation exercise were high yield (top 15 percent farmers' yield), medium prices (1989-1990 dry-season prices), 60 percent irrigation system efficiency, availability of inputs and marketing facilities, and, of course, the acceptance of the cropping schedules by the farmers. The best combinations were rice and lowland potato at LVRIS and rice and garlic at UTRIS (Table 22).

Table 22. Simulated crop areas, total production costs, gross production value, farm family income and collectible irrigation service fee, LVRIS and UTRIS.

Crop	Crop area, (ha)		Production costs	Total gross production value	Total farm family income	Collectible irrigation service fee
	Non-rice	Rice				
			---------in '000 pesos--------			
The Laoag-Vintar River Irrigation System						
Potato	1,254	690	35,820	423,546	387,726	1,082
Garlic	1,600	557	57,648	139,685	82,037	1,138
Tomato	1,600	557	15,258	90,725	77,792	1,138
Corn	1,600	557	12,933	53,925	38 667	1,138
Peanut	1,254	690	12,721	46,970	34,667	1,082
Wheat	1,600	557	10,081	35,557	25,476	1,138
Rice	0	1,305	7,887	32,625	24,738	979
Mungbean	1,600	557	8,249	30,821	22,572	1,138
The Upper Talavera River Irrigation System						
Garlic	1,600	300	50,702	135,500	93,189	1,103
Onion	1,600	300	42,312	115,500	64,798	1,103
Corn	1,352	300	11,776	41,300	29,525	972
Peanut	1,500	224	16,725	39,350	22,624	984
Mungbean	2,000	240	13,849	30,000	23,951	1,138
Rice	0	897	6,911	22,425	15,514	785
Soybean	1,580	368	18,635	30,530	11,895	1,152

Source: Cablayan et al. 1990b.

However, at estimated low prices, the rice and hybrid corn alternative provided the best combination in terms of total farm family income. This is consistent with the earlier projections made regarding hybrid corn as an alternative irrigated dry-season crop in Luzon. Recent yields of lowland potato crops obtained in farmers' fields at LVRIS have been very promising. The limited supply of seedling materials appears to be the major constraint. However, plans are underway for establishing a tissue culture laboratory to provide a viable supply of seed materials permanently at LVRIS and its adjacent areas.

CHAPTER 7

Farmers' Decisions to Diversify

AMONG THE NUMEROUS factors that affect farmers' decisions to diversify in irrigated areas in the dry season, the economic factors appear to dominate all other considerations, particularly the marketing aspects where arguments inferred from data point convincingly toward a market-driven orientation of crop diversification. If there is a market for non-rice crops, then farmers will seek ways and means to produce the demanded crops. Profit and income maximization as well as community status are dominant motives behind the farmers' decisions to diversify (Kikuchi 1989).

Conceptual aggregation of factors and relationships affecting farmers' decisions to diversify are illustrated in Figure 3: the physical and institutional factors on the left, the economic and social factors on the right, and the production technology on top. This conceptual presentation actually evolved from earlier analyses and studies done on the farmers' decision-making process.

DECISION-MAKING MODEL

A study was undertaken to determine the economic, institutional and physical factors behind the successful adoption and continued cultivation of non-rice crops as perceived by the farmers (Intal and Valera 1989). Many farmers (266 to be exact) were interviewed as to their perceptions on the conditions conducive to the successful and continued cultivation of non-rice crops in four irrigation systems in Luzon in the dry season. The non-rice crops planted by farmers in these systems were onion, garlic, mungbean, tobacco, tomato, peanut and corn.

A descriptive decision-making model was used to analyze the responses of farmers regarding economic and physical factors. The model was validated using the responses of farmers for all crops excepting mungbean. The case of the mungbean crop was not really a free choice situation, since NIA programmed the area specifically for mungbean production. This outcome suggests that the model is more applicable to free choice situations where farmers have a number of alternative crops to choose from (Intal and Valera 1986).

The results of the cropping decision-making model yielded the following conditions favorable to the adoption of crop diversification in 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; nearby farmers who planted non-rice crops; wet season and other sources of income providing the family's rice consumption requirement for the year; the crop being perceived as technically feasible (land suitable for the crop, adequate irrigation water for the crop, right timing for the dry season), and as economically feasible (crop being readily marketable, with credit and labor being available); the farmers' belief that the crop would yield much higher returns than rice and not just marginally so; an assured selling price (as in a contract growing scheme) or the market price of the crop not fluctuating too much; and the presence of support structures such as technical assistance, a credit mechanism and a viable market system.

Based on the results of this study, a clearer view of the factors directly relating to farmers' decisions to diversify in the dry season has emerged as exemplified in Figure 3. Another decision-making model was also used to explain farmers' decisions to diversify in Indonesia (IIMI 1987a). However, the foregoing study provided a more comprehensive explanation but not enough specification as to the degree of influence of each factor or condition on the farmers' decision-making process. Nonetheless, the study contributed to a better understanding of the factors underlying farmers' decisions to diversify.

POTENTIAL OF OTHER NIA SYSTEMS FOR CROP DIVERSIFICATION

The results of several studies (IIMI 1990 and results of studies as presented in the National Workshop on Irrigation Management for Rice-Based Farming Systems, sponsored by IIMI-IRRI. CEC, University of the Philippines, Los Banos, College, Laguna, the Philippines. 10-11 September 1990.) have shown that the increase in area irrigated for crop diversification in the dry season should not be confined to existing systems already diversifying but extended to other systems as well.

The potential of other systems, particularly in Luzon, was explored based on the land suitability, water availability and proximity to markets. The most promising systems for crop diversification in the dry season are located in Region III, in the provinces of Bulacan, Tarlac, Pampanga and Nueva Ecija. Collectively, the estimated irrigated areas with highly suitable soils and deficient rainfall, total about 40,000 ha. In the command area of the Upper Pampanga River Integrated Irrigation Systems (UPRIIS) alone, at least 20,000 ha have soils highly suitable for diversified cropping and the remaining areas are found in the irrigation systems of Tarlac, Bulacan and Pampanga.

With a good road network, transport facilities and proximity to Metro Manila, markets (input and output) are the main advantages of these systems. The disadvantage of these sites, on the other hand, is ironically, precisely due to the proximity to alternative sources of livelihood for farmers in the dry season, being near industrial areas in Metro Manila. Notwithstanding this opposing argument, these systems still have the physical and, to some extent, economic environments favorable to diversified cropping in the dry season. Of course, improvement in irrigation management will have to be carried out as an integral part in realizing the potential identified.

CHAPTER 8

Conclusions and Recommendations

AMONG THE FACTORS that have significantly influenced the adoption of crop diversification in the dry season, the economic factors appear to be the foremost considered by farmers. In the Luzon systems (UTRIS, LVRIS, SFRIS) where crop diversification has been traditionally practiced, markets are well-established. In the Mindanao systems (ARIP, BARIS), while the markets are established, the profitability is not attractive enough to shift from irrigated rice to irrigated corn in the dry season.

What is dominant among the production risks is the risk associated with the market prices of non-rice crops. The relative instability of prices, particularly for non-cereal, non-rice crops, is indicative of the need for better postharvest facilities for these crops. This will alleviate the price risks that the farmers have to face.

With an effective market mechanism, credit does not appear to be a constraint for farmers. However, better access to production inputs and technology should be made available. Labor is also not a constraint but availability of suitable land is. However, with a flexible tenancy arrangement this constraint is mitigated.

Among the non-rice crops grown, there is indicative potential for lowland white potato and hybrid corn. At LVRIS, potato is a promising crop if the problem of the availability of seed material is solved. The production of hybrid corn, particularly in the irrigation systems in Luzon, is another bright prospect. This is due to the proximity of these areas to the Metro Manila markets.

To a large extent, the economic factors are significantly influenced by externalities which the farmers, irrigation agencies or government policies cannot address. However, the results of the studies on the technical and institutional factors, lead to a better understanding of irrigated crop diversification in the dry season. With this, practices and procedures were identified that can be used in improving the management of irrigation systems. With the improvement of irrigation systems, farmers will be able to have flexibility in their choice of crops in response to whichever is more profitable. Farmers should have the flexibility to adopt both rice and non-rice crops in the most effective way possible.

Farmers have developed effective irrigation and drainage methods for non-rice crops, without removing rice dikes used for rice cultivation in the wet season. Additional farm ditches are built in the case of plot to plot irrigation in the case of onion and garlic. Farmers are well-adept in irrigating non-rice crops in the dry season.

With the low volume flow rate available from the secondary canals in the dry season, farmers have to take turns in generating enough head to irrigate non-rice crops. The optimum turnout service area should be small and be able to effectively serve, on the average, about 10 farmers. With this number, sharing and distribution will be possible.

Non-rice crops demand less water than rice but in larger volume flow rates. With higher volume flow rates, there should be a greater frequency of regulating the structures in the main and lateral canals, to afford better control and prevent conveyance losses.

A set of guidelines on irrigation management was field-tested in close collaboration with the NIA staff at LVRIS and UTRIS. The results of this indicated improvements in terms of better distribution and increase in area irrigated in the dry season. These guidelines embodied the following principles for improving irrigation system performance in irrigating both rice and non-rice crops in the dry season: improved operating rules appropriate to intermittent demand; very close collaboration with the Irrigators' Association in developing and implementing seasonal operating plans and schedules; equitable and reliable delivery schedules; improved monitoring in the implementation of delivery schedules; a clear policy for dealing with any departures from the agreed-upon schedules; and enhanced intensity of management and better-motivated operations staff to achieve these requirements.

The foregoing findings and the recommendations, if implemented, will lead to the optimization of soil and water resources in irrigation systems for the production of both rice and non-rice crops in the dry season.

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78

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80