DESIGN AND ANALYSIS OF APPROPRIATE TECHNOLOGY FOR SMALL FARMERS: CROPPING SYSTEMS RESEARCH IN THE PHILIPPINES

By

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ABSTRACT

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The invention of early maturing and high yielding rice varieties has opened up possibilities of increased production and incomes for small farmers in Asia and elsewhere. However, the new varieties were developed under optimal conditions not commonly found on small farms. Therefore, though yields on experiment stations have improved markedly, average farm yields remain low.

Agricultural and social scientists are now realizing that greater attention should be given to the specific environmental circumstances facing farmers, socioeconomic as well as agroclimatic, before and during new technology development. Accordingly, the International Rice Research Institute began technology development for small farmers by undertaking experimentation on farmers' fields in several agroclimatic situations. This study formed part of IRRI's Cropping Systems Program research efforts in rainfed lowland areas of Iloilo, the Philippines, applying a modified methodological approach to identifying and evaluating appropriate new technologies.

The research strategy focused on obtaining and using primarily qualitative information provided directly through informal farm interviews to gain an increased understanding of the local farm system. All aspects with an important influence on farmers' agricultural production decisions were considered. That information, combined with quantitative information gathered as part of the overall cropping system research effort, was utilized to invent several notional (or potential) new technologies intended to alleviate some of the production constraints facing farmers in Iloilo. The notional technologies were then ranked according to a number of performance criteria cited by farmers as important. Ratoon rice, the highest ranked technology, was then evaluated using a linear programming model to determine (a) the minimum yields required for adoption, and (b) the potential economic benefit to farmers should the notional technology be developed by agricultural scientists.

The study results clearly indicate the desirability and feasibility of ex-ante evaluation of existing and notional new technologies for their potential suitability to the socioeconomic and agroclimatic circumstances faced by small farmers. The issues of generalizability of research results and the establishment of research priorities are addressed, along with the specification of a methodology for a farmer-oriented research approach as a potential tool for increasing small farm productivity and promoting rural development.

"There was the story of an American who watched a Filipino farmer while working his fields. He noticed that after a few hours of work, the Filipino would go up on the back of his carabao and steer it to a cozy and cool place under a big mango tree, his sombalilo (native hat) over his face, and then lie motionless for sometime while his animal ate the grass growing under its feet.

Curious at the phenomenon, the American finally went to where the Filipino was. Seeing that the Filipino was awake, the American asked, "How come you stopped working so early?" The Filipino smiled and asked the American why he wanted him to continue working. "So you can plant some more!" the American replied.

"Why should I plant more?" the Filipino asked.

"So you can harvest more later," again the American replied.

"Why do you want me to harvest some more later?"

"So you can sell some more and earn more money!"

"Why do you want me to earn more money?"

"So you can afford the best things in life!"

"Sir," the Filipino finally emphatically replied, "lying down here is the best thing in life for me!" He smiled at the American and went back to rest."

Ramon A. Tagle, The World and You.
Chapter 2, Philippine Value Orientation.

To Gloria,

For her love,

patience, and

understanding,

and to

Jimmy,

Jennifer, and

John Christopher

ACKNOWLEDGMENTS

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Finally, the largest debt of gratitude is owed to the Iloilo farmers and their families, who generously gave of their time to help me to understand their agricultural activities and the adverse conditions they face. Without their patience and willingness to suffer through many long and tiring interviews, this study could never have been completed. Special recognition goes to Nilda Tejada, who acted as my interpreter and translator until I was able to communicate with the farmers directly. Lastly, to my family in Iloilo, the Tamons, I owe a great deal of thanks. They took me in as a member of the family, gave me love and encouragement, and taught me how to communicate with the Iloilo farmers in their own language.

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CHAPTER 1

INTRODUCTION

The advent of new agricultural production technology has opened up possibilities of increased production and a higher standard of living for farmers in Asia and around the world. A "quantum jump" in production potential materialized in the early 1960's with the breeding of high yielding varieties (HYVs), which could achieve double or triple the yield of traditional varieties. However, rarely does new technology represent a change in just one input or its use, but rather it often prescribes a number of changes in the behavior of farmers. For example, the increases in rice production potential provided by the modern rice varieties hinge upon adequate supplies of material inputs, such as fertilizer, pesticides and herbicides, and a fairly high degree of water control. The benefits of new technology may substantially decrease if agroclimatic and socio-economic conditions do not permit farmers to adopt the entire "package" of agronomic practices.

New rice varieties were bred under lowland irrigated conditions, and hence it is in this environment that they perform best. In order to enhance varietal acceptability under a wider range of agroclimatic conditions, plant breeders have selected and bred varieties for additional traits, including pest and disease resistance and drought tolerance. The reduction of the amount of time needed from planting to harvest has come about th

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about through the development of varieties with low photoperiod sensitivity.[1/] Varieties possessing this characteristic mature in a more or less constant period of time, regardless of day length. Traditional rice varieties generally mature during the same period each year, each variety responding to its own particular day length requirement. A traditional crop is often in the field for six to eight months before harvest. Modern varieties have tended to be of the early to intermediate maturing type. The principal advantage of early maturing varieties (EMVS) lies not in an increase in yield potential or pest resistance, but rather in their suitability for multiple cropping systems where more than one crop is grown sequentially on the same land during one year (Harwood, 1976).

Despite intensive breeding efforts, the range of environmental conditions under which modern varieties deliver significantly increased benefits has not greatly broadened (Herdt and Barker, 1977). This is evidenced by the fact that while palay[2/] yields on experiment stations are high (six to eight tons per hectare), average yields in the Philippines remain low (less than two tons per hectare). Given this information, one would suspect that technologies developed at the experiment station may not be well adapted to specific farm and community systems prevalent in Asia.

1/ Photoperiod is the period of light exposure in a 24-hour cycle that controls the growth and development of certain plants and animals. Highly photoperiod sensitive rice varieties will develop only under specific day length conditions.

2/ Palay is the Tagalog word for rough (unshelled) rice grain.

Economists are recognizing that greater consideration should be given to environmental requirements, both agroclimatic and socioeconomic, in the early stages of new rice technology development. According to Barker and Herdt (1978), approximately one-third of the world's rice area is non-irrigated, rainfed land. Rainfed area is concentrated in South and Southeast Asia, with more than one million hectares cultivated in each of seven countries (Table 1.1). Over one-half of the total rice area in all of South and Southeast Asia is strictly rainfed. Most of the non-irrigated area is occupied by small farmers, who in general do not possess sufficient resources to meet the capital and ecological requirements of the modern varieties (Barlow, 1978). With the exception of the Philippines, where 70 percent of the rainfed area is planted to modern varieties, rainfed areas are planted almost exclusively to traditional varieties (Barker & Herdt, 1978).

While it is believed that water control (or lack thereof) is the major impediment to the adoption of modern technology, other factors may play equally important roles. Capital, including cash for variable factor inputs, is a scarce resource. Larger farmers have a better chance to overcome this limitation, as access to formal credit markets is facilitated when sufficient resources (e.g. land) can be used as collateral for input loans. Small landholders and tenant farmers have lower credit ceilings due to lack of collateral, and may not be able to borrow

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Table 1.1. South and Southeast Asian countries with 1 million ha or more or rainfed rice by rank, 1973-75.

	Area in rainfed rice	
	(million ha)	(%)
India	18.1	49
Eastern [a/]	9.9	51
Other	8.2	46
Bangladesh	4.6	48
Burma	4.3	84
Vietnam	3.7	71
Thailand	3.6	69
Indonesia	3.4	39
Philippines	1.6	46
Other S & SE Asia	1.0	29
Average	5.0	54

a/ Eastern U.P., Bihar, W. Bengal, Assam and Orissa.

Source: Barker and Herdt, 1978.

in formal markets at all. The cost of capital is often higher in the informal credit system, with interest rates commonly ranging from 50 to 200 percent per annum.3/

Relative factor input and output price changes affect the attractiveness of new technologies over time. However, disincentives for rainfed rice farmers extend well beyond pricing mechanisms. Land fragmentation, small farm size, inappropriate technology and lack of technical knowledge on how to use inputs are common impediments to the adoption of more productive farming technologies (Barker and Herdt, 1978). Extension programs and input delivery systems generally are not as well developed in the rainfed as in irrigated areas. Government policies and programs can be used to stimulate or retard the adoption of new technologies. Often these are developed without due regard for the particular needs and problems of small farmers and the inherent uncertainties of agricultural production.4/

Certain aspects of modern technologies can impede their own adoption. For example, non-photoperiod-sensitive short duration varieties planted at the beginning of a wet season need to be harvested during the rainy

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3/ This statement is based upon the author's discussions with farmers and lenders in the study area.

4/ A case in point is the experience of an agricultural credit program in the Philippines. Farmers received individual loans, but were placed in repayment groups. In order for any farmer-group member to receive a loan the following year, all group members must have repaid all outstanding previous loans. If one farmer-group member sustained a poor crop-year and could not repay his loan, none of the group members could receive loans in the future. These rules led to the elimination of most small farmers as clients after the first year.

season.[5/] Fields remain flooded during the harvest, and continual rain does not allow drying of palay on the fields. The difficulty of the threshing operation is increased, due to greater adhesion of grains to the panicles. Grains often germinate or rot between the time the rice stalks are cut until they are threshed and dried.

Thus, it can be seen that new technologies can create new problems which must be solved with further innovation before increased adoption by farmers will take place. However, the alternatives being developed to overcome the new problems (e.g. mechanical threshers, mechanical grain dryers) are usually capital intensive, and may present further impediments to adoption by farmers with severe capital limitations.

Farming Systems Research

The need to achieve an understanding of farming systems as a means of identifying farm problems and technologies for their alleviation is now being recognized. Substantial efforts in the development of farming systems research have been made by Collinson (1972, 1979), National Research Council (1974), Norman (1976, 1978), Ruthenberg (1976), CIMMYT (1980) and many others.

While the precise definition of what constitutes a farming system is elusive, the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has published a description worthy of quotation here:

5/ A widely used rice variety in the Philippines, IR-36, has a maturation period of 105-115 days, depending upon weather conditions and planting method. Rainfed rice is commonly grown in areas with five or more wet months (200 mm/month) during a growing season (IRRI, 1978).

> A farming system (or farm system or whole farm system) is not simply a collection of crops and animals to which one can apply this input or that. Rather, it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences with the strands held and manipulated by a person called the farmer who, given his preferences and aspirations, attempts to produce output from the inputs and technology available to him. It is the farmer's unique understanding of his immediate environment, both natural and socio-economic, that results in his (particular) farming system (CGIAR- TAC, 1978).

While the TAC description of a farming system appears to lack clarity, it does bring out one key concept; the farmer is the center of attention, rather than the plants and animals he manages. This is a significant deviation from historical agricultural research, which has concentrated almost exclusively on the physical and technical aspects of plant and animal production.

What TAC calls a farming system is perhaps better named a farm production system. A more complete definition of a farming system should include household consumption activities, off-farm and non-farm employment activities, and marketing, transportation and processing systems. The same conceptual problems pointed out by Bonnen (1975) in researching changing U.S. agricultural systems are relevant to LDCs, though many of the components of traditional farming systems are not yet well developed.

Nevertheless, the farm production components of farming systems continue to be the focus of attention. This is probably based upon the assumption that the most significant problems exist in this component, hence calling for new technologies to be directed to areas where potential payoffs are greatest. Farming systems research "is aimed at enhancing the

efficacy[6/] of farming systems through the better focusing of agricultural research so as to facilitate the generation and testing of improved technology" (CGIAR-TAC, 1978).

According to TAC, the major activities involved in farming systems research are: (a) the collection and analysis of base data; (b) the study of existing farming systems; (c) the design of new farming systems; (d) farming systems experimentation; and (e) the evaluation and monitoring of new farming systems.

Cropping Systems Research

Cropping systems research is a subset of farm production systems research as it was described earlier by CGIAR-TAC (1978). The focus is on crop enterprises, especially annual crops which can be combined to form cropping patterns.[7/] Harwood (1976) defines a cropping system as:

> the cropping patterns utilized on a given farm and their interaction with farm resources, other farm enterprises and the available technology which determine their makeup.

A more restrictive definition of a cropping system is given by Zandstra (1976):

> The cropping system can be defined as the crop production enterprises used to derive benefits from a given resource base and specific environmental conditions.

6/ "Efficacy" implies relevance to the objectives of the CGIAR, i.e. to research "benefitting the majority of farmers in low income countries and on commodities representing important sources of food for the developing countries." (CGIAR, 1977).

7/ A cropping pattern is the yearly sequence and spatial arrangement of crops or of crops and fallow on a given area (Harwood, 1976).

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Implicit in Zandstra's definition is the idea that cropping systems research is confined to the farm's crop production enterprises. It does not address itself to changes in resource allocation among crop activities, non-crop farm activities, and non-farm and off-farm activities. If one accepts the more restrictive definition, then cropping systems research becomes an identifiable component of a subset of farming systems research.

It may seem that intensive study of one component of a farming system is too limited in scope. The danger in studying components of the farming system is that significant system improvement possibilities or constraints may be overlooked.[8/] On the other hand, crop production systems themselves are extremely complicated due to the large number of potentially relevant variables involved. This calls for intensive and integrated research in a number of different disciplines (agronomy, entomology, soil science, weed science and economics) on a number of different crops (e.g. rice, corn, mungbean, and cowpea) in a number of different agroclimatic and socioeconomic environments.

Given the complexity of cropping systems as defined, it appears that the decision to limit the research environment is a reasonable one. Furthermore, since cropping systems research begins with the study of existing systems in a given area, production problems may be identified which do not pertain to cropping systems research. In such cases, collaborative research efforts with other institutions would be in order.

8/ A potential beneficial animal-crop production system, rice and fish in lowland paddies, has been identified by Central Luzon State University (1978).

The Cropping Systems Program at IRRI

Research on cropping systems at the International Rice Research Institute (IRRI) was begun in the late 1960's by Richard Bradfield. His article (1972) reveals techniques for fitting a variety of legumes and other crops between rice plantings, with the primary objectives of improved human nutrition and soil fertility maintenance. Through his innovative experiments, he revealed the opportunities available for more intensive and diverse cropping.

In the early 1970's, research emphasis shifted from determining productivity of new or improved cropping patterns to the study of cropping patterns on existing farms where rice was the basic crop. In 1974, the Cropping Systems Program (CSP) was enlarged to include a multidisciplinary team to undertake studies of existing and improved cropping patterns.

For reasons mentioned at the beginning of this chapter, the CSP chose to focus efforts on rainfed lowland and upland rice areas in South and Southeast Asia. Priority was given to areas where it was possible to increase cropping intensity, i.e. the number of crops planted per growing season on a single unit of land.

The CSP concentrated on resource utilization on small rice farms, seeking to increase the benefits derived by crop production from available physical resources (e.g. rainfall, solar radiation, and soil) that are not readily modifiable (Zandstra, 1978). It also considered biological and economic factors at the farm level as they influence the performance of cropping systems. Though CSP research was carried out in specific sites, the objective was the development of technologies, including new ways of

combining crops into cropping patterns, which were appropriate for a large number of areas with similar climatic and physical conditions. Therefore, factors in the community or on the farm which restrict the adoption of new techniques did not necessarily force the abandonment of research on those techniques. A large part of the CSP on-going effort was focused both on the generation of component technology[9/] for cropping patterns, and on management of improved technology. The generation of new component technology depended upon feedback from CSP researchers to biological scientists at IRRI.[10/]

The Problem Setting

In 1975, the CSP began research in a rainfed rice growing area in Iloilo Province, Panay Island, West Visayas, Philippines (Figure 1.1). The research site was originally selected for its agroclimatic representativeness in terms of soils, water management, weather and geomorphic land relationships.

From 1975 to 1979, the CSP carried out the following activities at the site:

9/ Component technology involves changes in the management of single crops or crop mixtures which occupy a field during a single crop cycle.

10/ An example of feedback from an economist to plant breeders is presented in Chapman (1979).

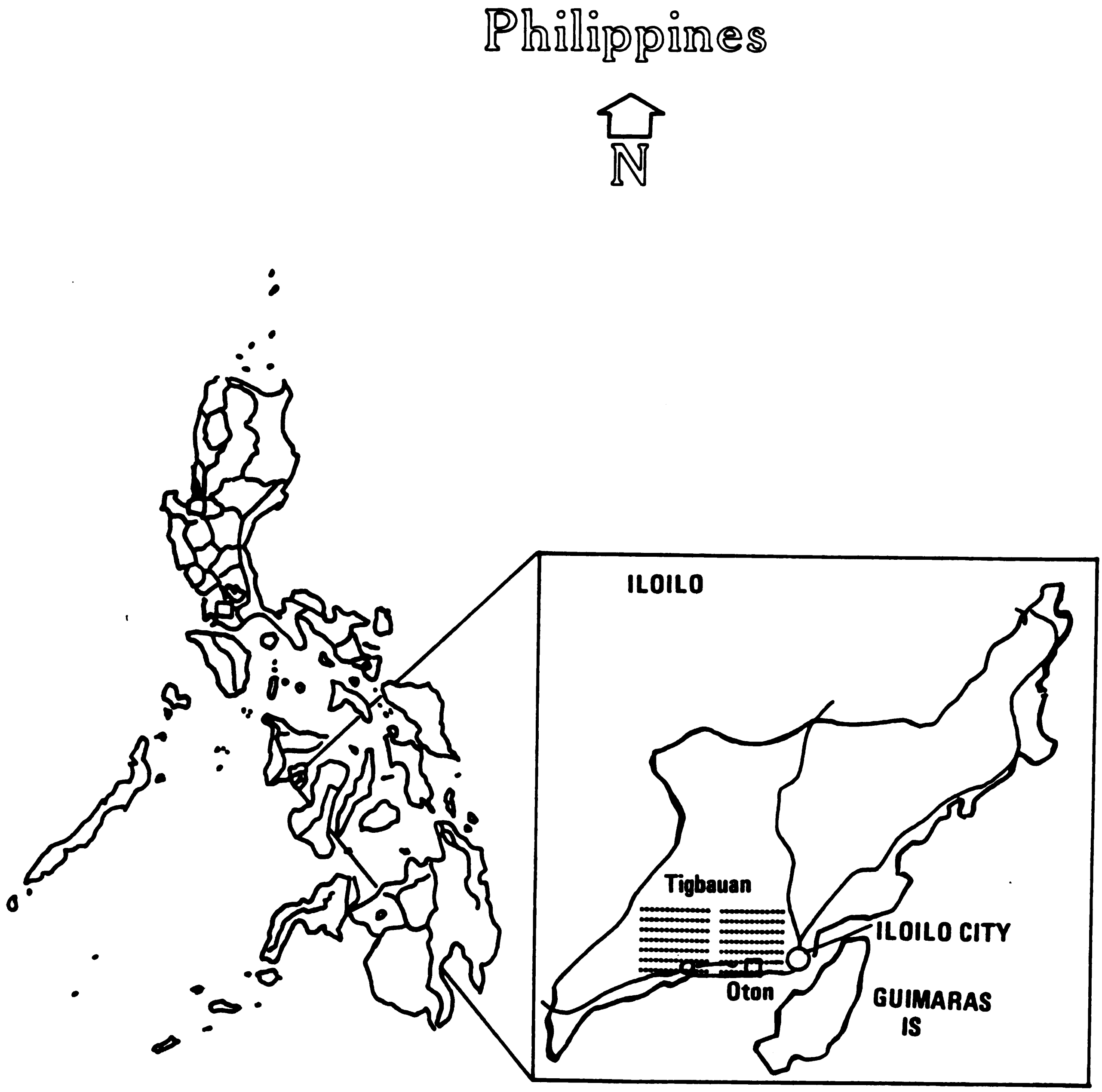

Figure 1.1. Location of the Iloilo research site.

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1. In early 1975, a baseline survey was taken of about 25 percent of all farmers in the site area (241 respondents). From baseline information, 45 farmers were chosen at random to participate in an intensive farm record-keeping study. Much of the information for the site description was provided by the selected farmers, who also provided a source of feedback for cropping systems researchers.
2. The major function of the Iloilo Outreach site was cropping pattern testing, including examination of the factors determining pattern adaptation and the effectiveness of individual management components within the patterns (Magbanua, et. al., 1977). Extensive field experiments were conducted to generalize and fine-tune cropping pattern components. Component technology research examined such subjects as insect pest and disease management, weed control, soil fertility, tillage and varietal performance.
3. Farm-household record-keeping activities were undertaken which involved mainly two aspects: (a) the collection and analysis of input-output data from experimental cropping pattern test fields; and (b) the collection of input-output data and prices to determine relative pattern profitabilities and resource flows in the farm-household economies of the 45 farmer cooperators.

A good measure of the degree of success of cropping systems research carried out in a specific area is the extent to which the recommendations

derived from research results are adopted by farmers in the area. Data in Table 1.2 present relative changes in cropping patterns (percent area planted to each pattern) at the Iloilo site during the time that the project has been in existence. Most significant are the changes from a single rice crop pattern to double rice crop or rice-upland crop patterns.

However, the information presented does not fully depict the actual situation in the rainfed portion of the Iloilo site. Shortly after the CSP began work in Iloilo, an irrigation project was begun which converted substantial hectarage within the site boundaries to partially and fully irrigated status by 1976. Nearly all of the villages where CSP farms were located had parts of their lands come under irrigation. As shown in Table 1.3, by 1978 over one-third of the area farmed by the 45 economic cooperators was fully or partially irrigated.

As previously stated, one of the major objectives of the CSP is to develop new technologies for rainfed lowland and upland areas. Therefore, some disaggregation of the data by water management class is useful in order to distinguish the effects of the research on the target population. In Table 1.4, the percentages of land cultivated by the 45 CSP economic cooperators devoted to different cropping patterns are displayed according to water management category. The figures demonstrate that technology focused on facilitating the establishment of two or more rice crops during a single growing season has been rapidly adopted by farmers with irrigated and partially irrigated land. The adoption rate of multiple rice cropping on rainfed lowland is much lower (19 percent to 30 percent). Also, the

Table 1.2. Percentage of cropland in various cropping patterns, Iloilo Outreach site, 1974-79.a/

Pattern	'74-'75	'75-'76	'76-'77	'77-'78	'78-'79
Two or more rice	5	20	38	49	45
One rice + one or more upland	11	28	30	17	31
Two or more upland	2	5	12	6	8
One rice + fallow	82	47	20	27	14
One upland + fallow	-	-	-	1	2

a/ The 1974-75 data represent average results of a 205 farm baseline survey conducted in January 1975. Data from 1975-79 came from a farm record keeping study on 45 farmers selected randomly from the baseline list.

Derived from: Genesila, Servano and Price, 1979.

Table 1.3. Percent of the total area of the farms of 45 economic cooperators under different water management classes, Iloilo, crop years 1976-79.

Crop Year	Irrigated	Partially irrigated	Rainfed		Total
			Lowland	Upland	
1976-77	15	7	68	10	100
1977-78	24	5	61	10	100
1978-79	23	11	56	10	100

Source: Genesila, Servano and Price, 1979.

Table 1.4. Percentage of cropland of 45 farmers in various cropping patterns by water management category, Iloilo Outreach Site, 1976-79.

Cropping Pattern	1976-77 a/	1977-78 b/	1978-79 b/
		Rainfed Lowland	
Two or more rice	30	19	28
One rice + one or more upland c/	43	30	46
Two or more upland	4	2	-
One rice + fallow	21	48	25
One upland + fallow	2	-	1
		Rainfed Upland	
Two or more rice	-	-	-
One rice + one or more upland	66	8	6
Two or more upland	21	73	74
One rice + fallow	-	6	-
One upland + fallow	13	13	20
		Partially Irrigated	
Two or more rice	39	90	71
One rice + one or more upland	-	3	22
Two or more upland	-	-	-
One rice + fallow	61	7	6
One upland + fallow	-	-	1
		Irrigated	
Two or more rice	96	100	96
One rice + one or more upland	-	-	3
Two or more upland	-	-	
One rice + fallow	4	-	-
One upland + fallow	-	-	1

a/ Derived from Roxas and Genesila, 1977.

b/ Source: Genesila, Servano and Price, 1979.

c/ Upland refers to all crops grown in the area other than rice.

double rice crop pattern for rainfed land is likely to be less stable because of year to year variations in rainfall intensity and duration. On the other hand, multiple cropping with one rice crop followed or preceeded by one or more upland crops has greatly increased in rainfed areas. Much of the increase is due to the fact that farmers are adopting the early maturing varieties (EMVs) in the rainfed areas, thus increasing the probability that sufficient moisture will be available for planting other crops before or after rice.

The importance of water and the utilization of EMVs in facilitating increased cropping intensity is clear. All of the study farmers were in relatively similar positions in 1974 with respect to water management, since none of the area was irrigated. Those farmers with land that came under full irrigation managed to muster sufficient labor, power and material resources to enable them to plant two or more rice crops beginning in 1976. This suggests that water may be a key resource limiting the adoption of more intensive cropping practices. At this point, it may be prudent to ask whether research on rainfed rice farming should continue, or whether dollars (or pesos) would be better invested in additional irrigation projects. However, as demonstrated in Table 1.1, there is a large amount of area in South and Southeast Asia that is not irrigated, nor is likely to be irrigated in the forseeable future given national and international resource limitations and priorities. It would seem, then, that continued research on rainfed agriculture is warranted, from both productivity and equity standpoints.

The Research Problem

Schultz' conclusion that there exist no significant inefficiencies in traditional agriculture, given the farm resource base, has become conventional wisdom (Schultz, 1964). This basically means that farmers do the best they can under the environmental and institutional conditions they face. The failure to recognize this fact has resulted in the waste of considerable research resources. New technologies emerging from the experiment station may be inappropriate under real farming conditions. Projects which are designed to improve the farm system often ratify the wisdom of the farmer.[11/]

This evidence suggests the presence of an information or communication gap; technologies being developed on research stations are not necessarily those which readily address the major production problems of farmers. There are a number of ways to learn about the problems that farmers face. The farmers themselves may be able to provide the quickest, easiest and most accurate answers.

Recent research emphasis has been placed on survey work drawing on anthropological techniques aimed at understanding rather than quantifying farm and community systems (Collinson, 1979). A major objective of adaptive agricultural research is to gain an understanding of what farmers do and why they do it. According to Collinson (1979), this emphasis has arisen from two types of pressures:

11/ A number of examples come to mind, though few of them are documented. The Plan Puebla project in Mexico was unable to find any high yielding corn varieties that could outyield the local variety (criollo) under farm conditions (Gladwin, 1978).

1. An increasing conviction that, despite advances in modelling techniques, quantification can only marginally improve understanding. It cannot provide answers (technological innovation).
2. Research resources are limited, and low cost, rapid coverage methodological approaches are necessary if agricultural economists are to make significant contributions to the development of technologies which directly attack farm problems.

A major contention of this study is that farmers can provide useful information, directly as well as indirectly, which can guide the cropping systems research process toward the solution of relevant production problems. In fact, farmers already play an important role in cropping systems research. They are the subjects of intensive record-keeping studies, and their reactions toward new technologies are observed and recorded. This study examines the possibility of increasing the utility to researchers of farmer informational input by formalizing the collection of certain types of information that are not necessarily obtained via commonly adopted methodological approaches (e.g. one-visit farm surveys asking only close-ended questions).

The specific research problem lies in using information about Iloilo rainfed farming systems in order to devise notional[12/] new technologies. These technologies, along with those currently in use, are then tested logically for their socioeconomic and agroclimatic feasibility in the prevalent farming system. The "best" notional technology is then tested using mathematical programming techniques to determine its potential benefits to Iloilo farmers.

Objectives

The objectives, or intended output of the research, can be stated as follows:

1. To identify the decision processes used by farmers in choosing and executing crops and crop combinations (cropping patterns).
2. To design a conceptual model reflecting the decision processes identified in Objective 1.
3. To use the model in the analysis and evaluation of specific technologies being developed at IRRI for testing in rainfed areas.
4. To propose notional new technologies based upon information regarding agroclimatic and socioeconomic conditions prevalent in the study area.
5. To evaluate the technological requirements and expected benefits of one notional technology, namely ratoon rice.

12/ The term "notional technology" was coined by Anderson and Hardaker (1979) to represent undeveloped or poorly-developed technologies with a recognized potential for adoption by farmers in specific ecological and socioeconomic circumstances.

In order to meet the above objectives, different kinds of information were analyzed. The information most relevant to this study was qualitative rather than quantitative, consisting mainly of answers given by farmers to open-ended questions, unsolicited information contributed by farmers, and personal observations regarding what farmers do and why they do it. To complement the qualitative information, data collected by the CSP were utilized when necessary. These data describe the production activities of 45 Iloilo farmers during the crop years 1977-78 and 1978-79. The data include costs and returns, physical input-output relationships, and prices.

Methodology

Of 45 CSP economic cooperators, 18 were located in fully rainfed areas. Twelve farmers were chosen for intensive monitoring and interview by the researcher. The criteria for choosing the number of farms to be studied were more practical than theoretical. The sample had to be small enough to enable the researcher to conduct numerous intensive formal and informal interviews, yet large enough to incorporate farms of different sizes, resource bases and management capacities.

The process of information collection and analysis followed during the course of the study consisted of recursive passes through five distinct phases: System exploration; system conceptualization; problem identification; notional technology conceptualization; and notional technology evaluation.

System exploration

Information was collected about farm and community systems and used to build a conceptual crop decision making model via:

1. Informal learning
   a. Informal interviews
   b. Accidental learning
2. Formal learning
   a. Observation
   b. Formal interviews
   c. Accidental learning

At the beginning of the field work, little was known about the system. Many farmer responses to questions did not seem clear or logical. Often, answers to questions introduced new concepts and ideas, which in turn brought to mind new sets of questions. After a number of interviews were held, with similar questions asked of different farmers, it was possible to begin to focus on those problems or aspects of problems that were common to most of the farmers in the study area.

What took place during the informal interview process was learning about the farm and community systems as farmers view them. As the learning process progressed, ideas about the system were formulated and then tested by means of further questioning and observation. Acoidental learning took place when answers to important questions were obtained, though the question had not been asked. Accidental learning played an important role at this point in the research, since not all relevant variables for the specific situation had been identified a priori. It was as important at this stage to learn what questions needed to be asked as it was to obtain the answers.

Having acquired a preliminary understanding of the local farm and community system, more formal and objective information was obtained in order to refine the ideas formulated during the informal learning process. First hand observation of farmers' cropping practices and the functioning of the total farm and community system also provided feedback regarding the accuracy of initial impressions. Observations that tended to support previous impressions provided no new information, while observations that conflicted with initial impressions caused those impressions to be re-evaluated informally. More formal interviewing, using pre-structured questionnaires, was focused on questions which were believed to be relevant and important, but which were not satisfactorily answered during the informal and observation stages. Formal interviews also contained open-ended questions which were asked of all farmers in the sample, with the answers being recorded for future reference. At times, new questions arose which required a return to the informal stage for re-exploration.

As outlined, the farmer information gathering process was iterative and interactive. The steps were not necessarily sequential. Learning took place at all steps during the course of the study. Information gathering was complete when the basic tenet of the economics of information was subjectively satisfied: the marginal value of additional learning equaled the marginal cost of obtaining further information.

System conceptualization

Concurrent with the exploratory phase, a conceptual picture of the system structure was constructed to enable the ordering of ideas about system behavior. A flow chart of a conceptual model was prepared in order to describe processes taking place in the system, and to identify the principal factors which influence farmers' cropping decisions. The objective was to look at farm processes from the farmers' point of view. Simplifying assumptions were minimized and observed or elicited decision rules were preferred over economic algorithms. After building the general framework, judgments were made as to which variables most limited farm productivity. For those parts of the farm system, more detail was incorporated in the model to improve its utility as a research tool.

Problem identification

With a better (though by no means complete) understanding of local farm systems, it was possible to identify farm-level constraints to increased productivity. Responding to the expressed desire on the part of many farmers for increased rice production, specific attention was focussed on increasing rice cropping intensity without violating perceived capital, labor, and ecological constraints.

Notional technology conceptualization

The conceptualization or "invention" of new technologies to address farm production problems comprised the fourth step in the research process. The exact means by which problem solutions are derived from problem identification is difficult to describe. It is as much as an art as it is a science, and depends largely upon the ability of researchers to analyze, synthesize and invent. It requires the creation of new concepts, or the modification of existing concepts. According to Anderson and Hardaker (1979):

> Notional new technologies are, because of their hypothetical nature, cheap to invent and bounded only by the imagination of the inventor. Since more fully developed technologies usually have their genesis as notions, attention to generating notional new technologies should not be disregarded. Evaluation of this category can range from intuition to analysis, but analytical appraisal is essentially confined to work on models rather than on real systems.

Notional technology evaluation

The last methodological step in this study involved preliminary evaluation of the notional technologies identified as a result of earlier steps. This included performing simple tests at first, such as consulting with farmers and other scientists, to make sure that the technologies met a number of important criteria which together determine biological feasibility, economic viability and social acceptability.[13/]

One technology that fared well in simple tests was then subjected to a quantitative analysis with the purpose of determining likely benefits to

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13/ Important criteria for the development of analytical techniques for farming systems research are simplicity and robustness. In order for a methodology to be applicable to the usual research environment in developing countries, quantitative models need to be relatively easy to build and use. They must not be too demanding of special analytical skills and advanced computer facilities. However, simple quantitative models need to be complemented by a great deal of qualitative information of the sort obtained in the early stages of the research described herein.

farmers and providing biological scientists with more specific information regarding its desirable characteristics under rainfed conditions. The mode of analysis was standard linear programming (LP). Prior knowledge was used to restrict the model to a range of feasible alternatives, and only information presumed crucial to the solution of the problem was explicity incorporated into the mathematical model.

Plan of the Study

The rest of this document is organized into six chapters. A description of the agroclimatic, biological and socioeconomic environments of the Iloilo research site is presented in Chapter 2. In Chapter 3, a conceptual model of the crop production decision process is described. Chapter 4 contains a narrative case history of conditions influencing technology adoption on a composite farm. The conceptual decision model, together with information presented in previous chapters, is used to test the feasibility and relative desirability of alternative current and notional technologies in Chapter 5. A linear programming analysis of a notional technology is presented in Chapter 6 as an example of how quantitative techniques can be used to help evaluate notional technologies and provide guidelines for their development. The implications of the study for farming systems research methodology are presented along with the summary and conclusions in Chapter 7.

CHAPTER 2

ENVIRONMENTAL ASPECTS OF ILOILO CROPPING SYSTEMS

There are three types of environments which can affect the makeup of cropping systems; the agroclimatic environment (weather and topography), the biological environment (soils, weeds, insects and diseases), and the socioeconomic environment (humans and institutions). In this chapter, a general discussion of the major factors from each environment which influence farmers cropping practices is presented.[1/]

The Agroclimatic Environment

Plants and animals need specific elements provided by the natural agroclimate, namely water, light, nutrients and a medium in which to grow. Different crops have different requirements for these elements, so the potential exists for the selection of crops or crop combinations which can grow well in a given climate either as complements or as substitutes. For example, crops with different water requirements, such as rice and corn, are usually grown in different seasons. Therefore, the planting of one crop does not necessarily preclude the planting on the same area of the other, as they are juxtaposed in time, if not in space. Crops which require similar agroclimatic conditions cannot be grown in the exact same space during a season, unless the growing season

1/ A description of the specific conditions encountered at the Iloilo site is contained in Appendices A, B and C.

is long enough to allow juxtaposition in time (sequential cropping).[2/] Between growing seasons, there are times when conditions are adequate for both wet season (flooded) crops and dry season (upland) crops.

An example of the preceding statement for the Iloilo rainfed area is presented in Figure 2.1. Time, in terms of months, is measured along the axes, while rice and upland crop growing seasons are depicted on the upper and lower portions respectively of the diagram. The rice-growing (drought-free) season usually lasts for 5-6 months (July-November). In other months, the probability of drought stress conditions for rice is higher. Upland crops can be grown during two periods of the year; at the beginning of the wet season (May to mid-June), and in the transition period from an overly wet to an overly dry state (mid-October to mid-February). From mid-February through April, upland crops on the field would likely suffer from drought stress, while from mid-June to mid-October, the probability of excessive moisture and flooding is high. The "competitive" period, when either rice or an upland crop can be grown, has a duration of just over one month (mid-October to late-November).

The seasons given for planting and growing rice and upland crops can be considered safe in the sense that in most years yield reductions will not occur then due to either drought stress or excessive moisture.

2/ Some modification of this statement is necessary. Two cultivars can never occupy exactly the same space simultaneously, but may be grown in the same area in alternating rows or sets of rows (intercropping, Zandstra, 1978). Partial time and space combination is a characteristic of relay cropping, where two or more cultivars are grown in sequence with the latter being planted before the harvest, but after flowering, of the former (Zandstra, 1978).

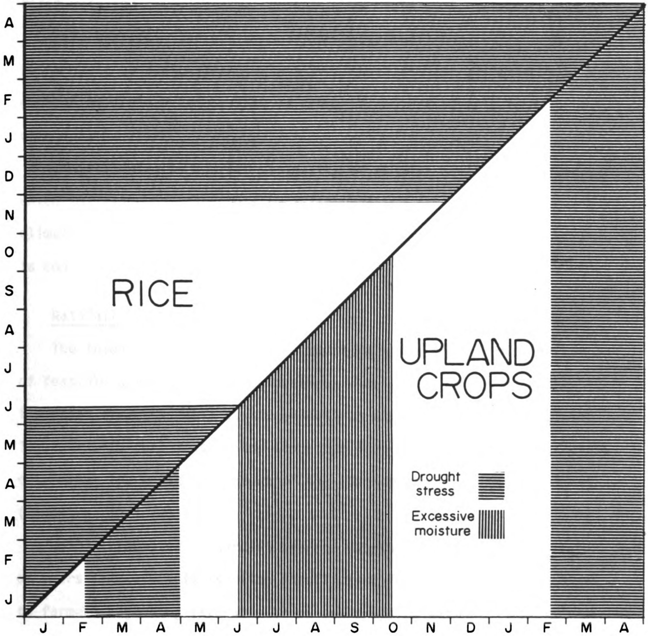

Figure 2.1. An agroclimatic map of cropping potential in the Iloilo rainfed area.

Note: The environmental conditions for rice are specified above the diagonal; those for upland crops below the diagonal. These conditions correspond to areas with 5-6 wet (> 200 mm) and 2-4 dry (< 100 mm) months per year.

Planting and/or harvesting outside those two periods involves increased risks with the level of risk increasing as crops spend more time out of the safe periods. One of the major objectives of cropping systems research is to design cropping patterns that will fit climatic conditions as closely as possible in order to protect farmers from unacceptable risks.

The following is a brief discussion of general agroclimatic factors which influence cropping potential. A detailed discussion of agroclimatic conditions at the Iloilo site and their effect on crop outcomes is contained in Appendix A.

Rainfall

The intensity, duration and variability of rainfall limit the range of feasible crops and cropping patterns that can be employed in non-irrigated areas, as well as the production potential of each crop. Together with soil texture and landscape (geomorphic) position, rainfall determines the moisture content of the rooting zone of a rainfed field (Zandstra, 1978 (a)).

While information regarding average rainfall patterns over a number of years is useful, it is often insufficient for basing recommendations to farmers regarding favorable crops and cropping patterns. Extremely important is the regularity with which farmers can expect a given amount of rain to fall during a certain period. The more stable the rainfall pattern, the greater is the farmer's capacity to execute the cropping pattern which he has chosen. The stability of rainfall, then, becomes as nearly as important to farmers as the actual quantity of rainfall.

Solar radiation

Crop physiologists have stressed the effects of solar radiation on crop production. Experimental evidence from IRRI studies suggests that the effects of sunlight on yield may have been over emphasized in previous research efforts (IRRI, 1975). In general, it is felt that minimum solar radiation levels in the tropics are above levels which would inhibit crop photosynthesis and production. On the other hand, high intensity solar radiation may indirectly affect crop yields by promoting evaporation and plant transpiration, thereby reducing the amount of moisture available in the root zone (IRRI, 1978).

Temperature

In the tropics, high temperatures cause temperate climate crops to develop rapidly by speeding up their biological clocks (Monteith, 1978). High temperatures shorten the grain-filling period of rice, thus reducing the potential productivity per crop. Potential crop production per year, however, is higher in the tropics than in the temperate zones because favorable temperatures for crop growth exist throughout the year, facilitating the growth of two or more crops annually (IRRI, 1977).

Day length

For modern rice varieties with relatively low degrees of photoperiod sensitivity, day length has ceased to be a critical factor. In general, the highest production potential for these varieties will be associated with the cooler, brighter periods of the year. Day length sensitive crops such as soybean and to a lesser extent mung bean, shorten their growth duration during the short-day (12 hours or less) growing season. While shortened growth duration may be desirable for increasing the potential for intensified cropping, crop yields may also be substantially reduced.

In many rainfed areas in the Philippines, the planting period for dryland crops (November-December) is characterized by short day length, low solar radiation, and mean daily temperatures above 27 degrees centigrade. These characteristics lead to rapid plant development with limited production potential.

Topography

Within a specific site, land-related factors alter water supply by influencing the rate of surface or sub-surface drainage into and away from a field (Morris and Zandstra, 1978). Natural and farmer-induced land drainage factors can vary the effective rice or dryland crop growing seasons. The same factors which alter field flooding regimes also affect the makeup of feasible and viable rice-based cropping systems.[3/]

The Biological Environment

Agroclimatic and biological factors can be distinguished mainly by the degree to which each factor can be controlled or modified. Most agroclimatic factors are either non-controllable (e.g. rainfall, solar radiation, winds, etc.) or weakly modifiable (landscape positions,

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3/ A detailed discussion of land-related factors and their effect on cropping potential is contained in Appendix A.

moisture regimes). Artificial irrigation[4/] is the only means of strongly modifying the agroclimate. Since this study focuses on conditions in strictly rainfed areas, artificial irrigation is not included as an agroclimatic variable.

Many biological factors, on the other hand, are strongly controllable using a variety of managerial techniques. Soil-related factors, such as deficiencies in vital nutrients for plant growth, can be modified by adding fertilizers or by planting crops which do not require large amounts of the absent nutrients. Insect pests can be controlled by the use of lethal chemicals, through the manipulation of biological relationships (pest-predator control), and by the use of crops and crop varieties resistant to attack from prevalent local pests. Plant diseases can be controlled through the reduction of insect populations which carry diseases, the use of lethal chemicals, or through the planting of resistant crops or varieties. Yield reduction due to competition from weeds in the field can be reduced by various land tillage practices, manual weedings, the use of large-canopy crops or varieties, by water management, and by the use of lethal chemicals.

The stability of the performance of any cropping pattern is strongly influenced by its biological envionment. Any change in cropping patterns will be reflected in a change in the biological environment. Research on these aspect of cropping systems is complicated, due to the large number of potential interactions which could take place simultaneously or sequentially, and due to the lag in time until full

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4/ Artificial irrigation includes field water from all sources other than rainfall, seepage and percolation, and surface runoff.

total effects are known. The importance of the interdependent effects of crops and cropping systems and the biological environment cannot be overstated.

A brief description is included here of the biological factors relevant to cropping systems. A discussion of experimental results in the Iloilo area related to prevalent biological conditions is contained in Appendix B.

Insects

Occurrence of insect pests varies from crop to crop, region to region, and even fluctuates during the year in one region (Zandstra, 1977). Insect populations are influenced by the crop present in the area at a certain time (host-pest relationship) and by agroclimatic factors such as temperature, humidity, air circulation (wind), rain and solar radiation intensity. In addition, the insect population includes insects which attack certain crops and insects which prey on the crop insects. Where predators are favored by the local environment, crop pest incidence may be reduced. The use of broad-spectrum pesticides may upset pest-predator population balances, and can be especially harmful if the pesticide is more lethal to the predators than to the insects attacking the crops (Kenmore, 1979).

Weeds

Different crops, methods of land preparation, water management and weed control practices cause changes in weed populations. Jereza and De Datta (1976) reported that a weed commonly found in flooded rice fields, *Scirpus maritimus*, persisted under continuous lowland rice culture but decreased with use of an upland-lowland crop rotation. Harwood and Bantilan (1974) found that rice field puddling greatly reduced the carryover of upland weeds from crop to crop.

In addition, agroclimatic factors such as rainfall, temperature, soil texture and flooding potential determine the types of weeds that can survive in a specific environmental complex.

Diseases

Canopy humidity, windspeeds, rain and temperature all play important roles in promoting or retarding the spread of diseases. The development of varieties or crops resistant to common diseases can reduce the likelihood of infection and the spread of diseases. The makeup of cropping patterns also influences disease occurrence, especially those diseases which are soil-born. Continuous cropping may facilitate the permanence of diseases by providing an ever-present host. Intercropping, on the other hand, can favorably change canopy characteristics to reduce disease incidence.

Soil-related factors

When the same or similar crops are grown for several cycles, soil fertility problems may develop. This results mainly from utilization of nutrients necessary for growth of certain kinds of crops without their replacement. Experimental evidence indicates that in most instances crop rotation is essential in order to maintain the productive capacity of the soil. Fixed nitrogen as a by-product of legume crop production is a well known auxilliary benefit as it promotes improved performance of succeding cereal crops.

The Socioeconomic Environment[5/]

The socioeconomic environment is comprised of factors not included in the agroclimatic or biological environments. More specifically, the disciplines of sociology and economics deal with and try to explain human and institutional behavior, and how they are affected by technological changes. Economics is concerned with choices regarding the allocation of limited resources to achieve given ends. Sociology, psychology, ethics and political science specify the limitations on choices through laws, customs and other expressions of value. Each individual, then, has his opportunity or choice set bounded by society, but he is free to choose within those bounds. If all values and outcomes are known (or if all probabilities are known), then economics can prescribe the reallocation of resources such that maximum utility or satisfaction is achieved. It is appropriate, then, to examine the economic resources that farms and communities have at their disposition.

Individual resources

Farmers exercise varying degrees of control over three types of resources: land, labor and capital.

Land. There are four variables which affect farmers' choices regarding land use: land type, tenure status, land area (farm size) and land distribution (fragmentation).

5/ A description of the specific socioeconomic conditions prevalent in the Iloilo area is presented in Appendix C. A brief case study of a typical Iloilo farm in Chapter 4 also contains socioeconomic information.

As demonstrated in Appendices A and B, the crop choice set open to farmers is influenced by the type of land he manages. However, some modifications can be made in land characteristics. Such modifications include bunding and leveling, fertilization and irrigation. Once modifications are made, land becomes a relatively fixed factor of production.

Land tenure also affects cropping decisions, especially those which concern the allocation of relatively variable factors of production (fertilizers, pesticides, etc). Farmers who receive a smaller return on their inputs (e.g. share-holders or lessees) would tend to use a lower quantity of inputs. It is possible to assume that, other things being equal, the productivity of farmers who pay rent in cash or in kind for use of their land would be less than that of farmers who own their land. This assumption, however, has not been validated empirically because other factors cannot be held constant.

Land area, or farm size, affects farmers' cropping decisions, usually in conjunction with labor and capital availabilities. Cropping on larger farms is likely to be less intensive if labor and capital resources are limited. Labor and capital are often good substitutes (e.g. hired human labor or machinery for cash or kind), so certain restrictions can be overcome. Community factors can affect capital-labor substitution. For example, a farmer may have (or have access to) sufficient capital to hire human labor, but he will not be able to do so if there is not an opportune supply of labor available. Labor-leisure preferences may also be important. A person controlling a large area may be able to meet his family's needs using less intensive traditional cropping methods, and so does not adopt new technology even though it may be monetarily profitable to do so (Simon, 1969).

Farmers with fragmented parcels are forced to incur extra costs in time and labor in moving from parcel to parcel. If parcels are widely dispersed, timely planting of crops may be inhibited, thus forcing modification of otherwise desirable cropping patterns. Field access due to fragmentation can also prevent farmers from carrying out their plans. If a farmer controls a parcel in a field which is surrounded by other parcels or by sectoral barriers, he must prepare and plant his land while there is still access (unplanted land) to it. Otherwise, he will either be forced to wait until other farmers have harvested their crops, or be responsible for damages to other parcels caused by passing through planted fields.

Labor. The majority of the labor required for planting crops on small rainfed farms in Iloilo is provided by members of the farm family. The assumption is often made, after measuring total and average labor use for different cropping systems, that there exists large amounts of excess family labor which can potentially be employed to increase cropping intensity. This assusmption, of course, takes into consideration the size (number of members) of the family, their sexes and ages, and their availability for farm work. Cropping systems and patterns can be designed to efficiently utilize family labor, with a major goal of increasing productive employment during traditional slack times and perhaps easing a bit the heavy demands made on family labor during periods when labor requirements are high and/or when labor supply is limited. Staggered planting and harvesting and multiple cropping represent means of "smoothing out" the labor requirement pattern. Factors in the community, such as off-farm and non-farm employment opportunities, school years, and other community traditions and responsibilities need to be taken into consideration. These factors can cause certain "rigidities" in the labor system which are not easily overcome, and perhaps should be treated as fixed factors when designing cropping patterns for specific regions.

Farm labor is not necessarily provided only by the family. In areas where substantial amounts of hired labor is utilized, the supply of labor in the community becomes important, determining wage rates and consequently the activities to which hired labor is allocated.

Capital. Capital can include all resources used in production, including land and labor (human capital). In its most liquid form, money, it can be used to purchase other more activity-specific forms of capital, such as household consumption goods, productive material inputs (e.g. seeds and fertilizers) and services (e.g. human and mechanized labor). Sources of liquid capital include proceeds from the following activities: sales of farm products, sales from non-farm household production (e.g. cotagge industry), sales of personal services (wages) and borrowing (credit). The ability to accumulate capital is affected by extra-farm conditions such as product prices, wage rates, local employment opportunities and credit ceilings.

Community resources

Individual farmers have little or no control over community resources and institutions. Important community factors influencing farmer decisions regarding crops and cropping patterns are prices and markets. In the absence of government intervention, input and product prices are determined by supply and demand conditions in local markets. Farmers may be unwilling to increase production of certain crops, even if the agro-climatic and biological environments are favorable, if no ready markets exist for the disposal of their produce or no assurance is given of minimum acceptable returns. Infrastructure (roads, transportation systems and physical marketing facilities) can play a crucial role in limiting or modifying the feasible combination of crops into cropping systems in local areas. Therefore, knowledge regarding these factors is essential when considering the universe of possible crops and technologies to be designed and studied by cropping systems researchers.

CHAPTER 3

A CONCEPTUAL MODEL OF FARMERS' CROPPING DECISIONS

In Chapter 2, a description was presented of the general types of variables which influence the decisions farmers make in carrying out their cropping activities. In this chapter, a conceptual decision model which schematically depicts the managerial sub-processes of decision making and execution of cropping activities is presented and discussed. The main purpose of the conceptual model is to provide a specific context within which proposed or existing farmer technologies can be evaluated.

Figure 3.1 depicts the process by which farmers combine general and specific types of information in order to formulate the decision rules which are used to select and execute crops and cropping patterns. Farmers acquire and use two types of information, positive and normative. Positive knowledge involves value-free concepts, while normative knowledge involves concepts of goodness and badness per se (Johnson and Zerby, 1973). When defining and analyzing problems, knowledge about the goodness and badness of outcomes is combined with non-normative knowledge to form prescriptions for future action (Johnson, 1961). The pragmatic philosophical position holds that the positive and normative are interdependent. For example, a farmer may have knowledge of certain weather patterns and their effect on crop outcomes. He must also possess knowledge about the goodness and badness of each of the possible outcomes in order to be able to make a right decision, i.e., one which maximizes the good and/or minimizes the bad.

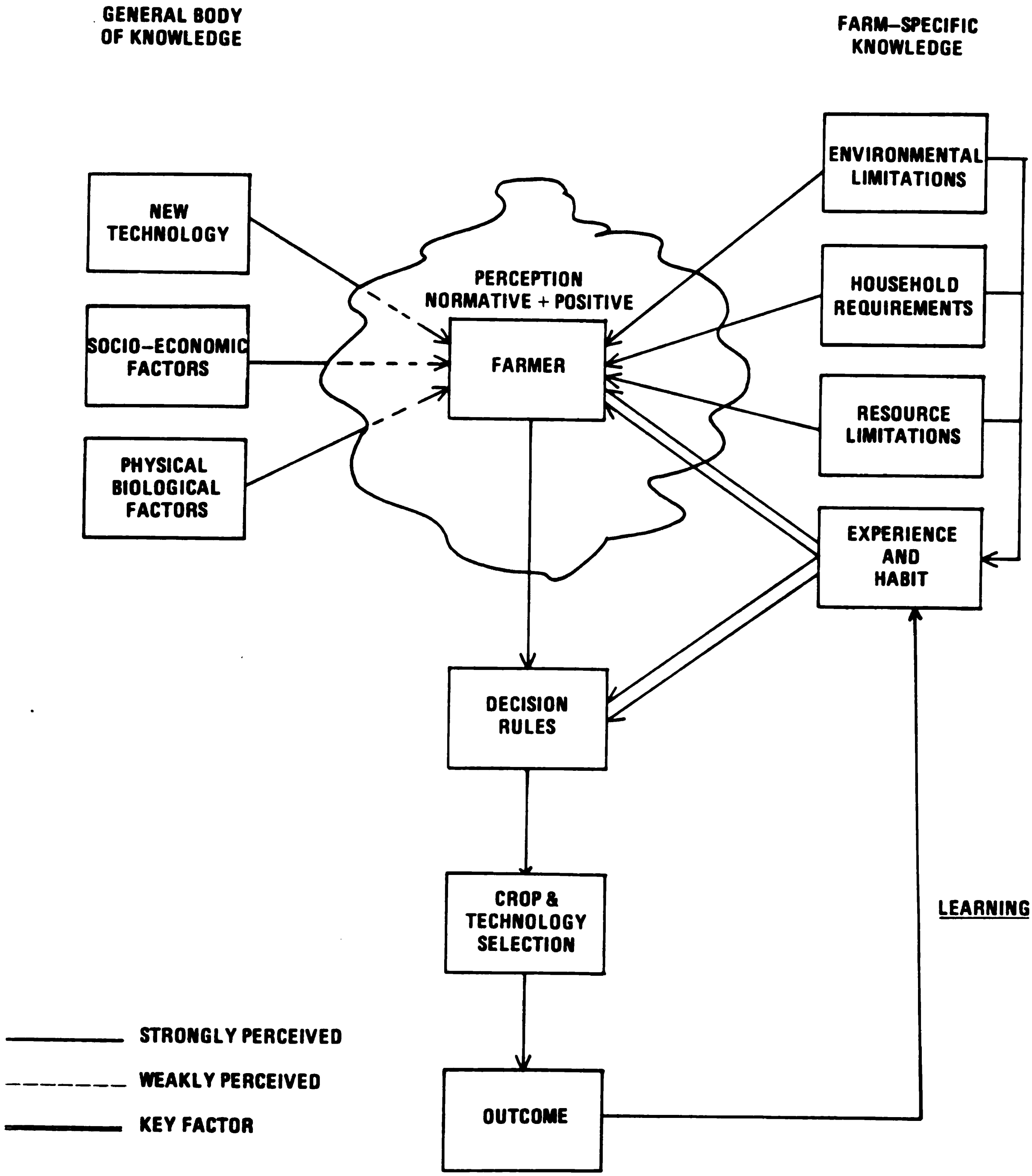

Figure 3.1. A descriptive model of the factors affecting farmers' cropping decisions.

There exists a general body of knowledge, both theoretical and empirical, which has been generated by disciplinary research in the physical, biological and social sciences. Farmers acquire knowledge regarding physical, biological and social factors and their interrelationships through formal (school) and non-formal (experience) learning processes. Since the amount of information generated by the scientific disciplines that one individual can obtain and comprehend is limited, only those elements which are known well enough to be usefully interpreted influence farming decisions. In general, social, physical and biological processes either do not affect the farmer directly or take place without his knowledge. Therefore, the effect of general factors on decision making is weak or negligible.

The knowledge gained in disciplinary research sometimes results in new discoveries which can be developed and adapted as new technolgies. Farmers may be aware of the new technology available, but only those technolgies with which farmers have actual experience can significantly affect their decisions. In Figure 3.1, general knowledge of new technology, socio-economic factors and physical-biological factors are shown as being weakly perceived by farmers, consequently resulting in a weak direct effect on the types of decision rules farmers derive.

Factors which are learned directly by farmers through experience play a more important cognitive role than general factors. A farmer may have little knowledge regarding the complex biological interactions between soils and plants, but through experiece he does know which crop grows best, and under which conditions, on a certain field or portion of a field.

Other factors such as household food requirements, the resource limitations which limit choices of crops and technologies, and prices of crops in local markets play a relatively large role in determining the cropping decisions made during the course of a season. Specific types of knowledge have a greater influence on the formation of decision rules than do more general types knowledge.

Decision rules are based not just on current knowledge, and experience, but also on previous experience. A young person who begins farming with little practical experience of his own is likely at first to adopt the decision rules that have been used in the past by those farmers with whom he is acquainted. Decision rules change over time with experience (crop outcomes) and with changes in technologies, environments, household requirements and resource levels. If regional environmental variables and technologies do not change, or change only slightly, a fairly stable set of decision rules may exist determined largely by experience and habit. When a significant change is introduced into the system, such as a new technology, then experience and habit are no longer sufficient to determine decision rules. The farmer learns about changes through observation and experience, and adjusts his decision rules according to what has been learned. At first, the farmer is uncertain about the effects of changes on the overall system, and hence decision rules will be only tentative until more knowledge is obtained. With increased observation and experience over time, uncertainties are reduced, and decision rules tend to stabilize. Dynamic systems are continually subjected to changing environmental and technological circumstances, so no decision rule is likely to be perfectly stable. Learning is therefore a continuous process.

Examples of the specific decision farmers make and the rules they use in carrying out crop activities will now be presented. This will be followed by discussion of the decision rule changes resulting from the adoption and adaptation of new technology in the Iloilo context (Chapter 4).

The General Model

A model is a conceptual representation of reality. Every decision cannot be included in the model without making it too cumbersome and difficult to understand. The model, then, abstracts from reality, and focuses on those decisions and actions which are essential to an adequate understanding of the reality being represented.

The flow chart in Figure 3.2 depicts the general kinds of management decisions farmers must make during the course of a crop season, for each crop planted on each different field. As mentioned previously, farms in Iloilo are generally made up of several, non-contiguous fields. For purposes of discussion here, a field is defined as a contiguous, homogeneously managed area of land of similar type and quality. Therefore, if a contiguous area of land is divided and planted to two different crops, it will be counted as two fields. Similarly, a contiguous area planted to the same crop will contain distinct fields if soil types and landscape positions differ.

The decision process begins during the dry season when no crops are growing on any field. In Iloilo, there are 2-4 dry months, with less than 100 mm rain per month. During these months, there is usually insufficient rainfall to support even highly drought-tolerant crops without supplementary irrigation except on the lowest landscape positions.

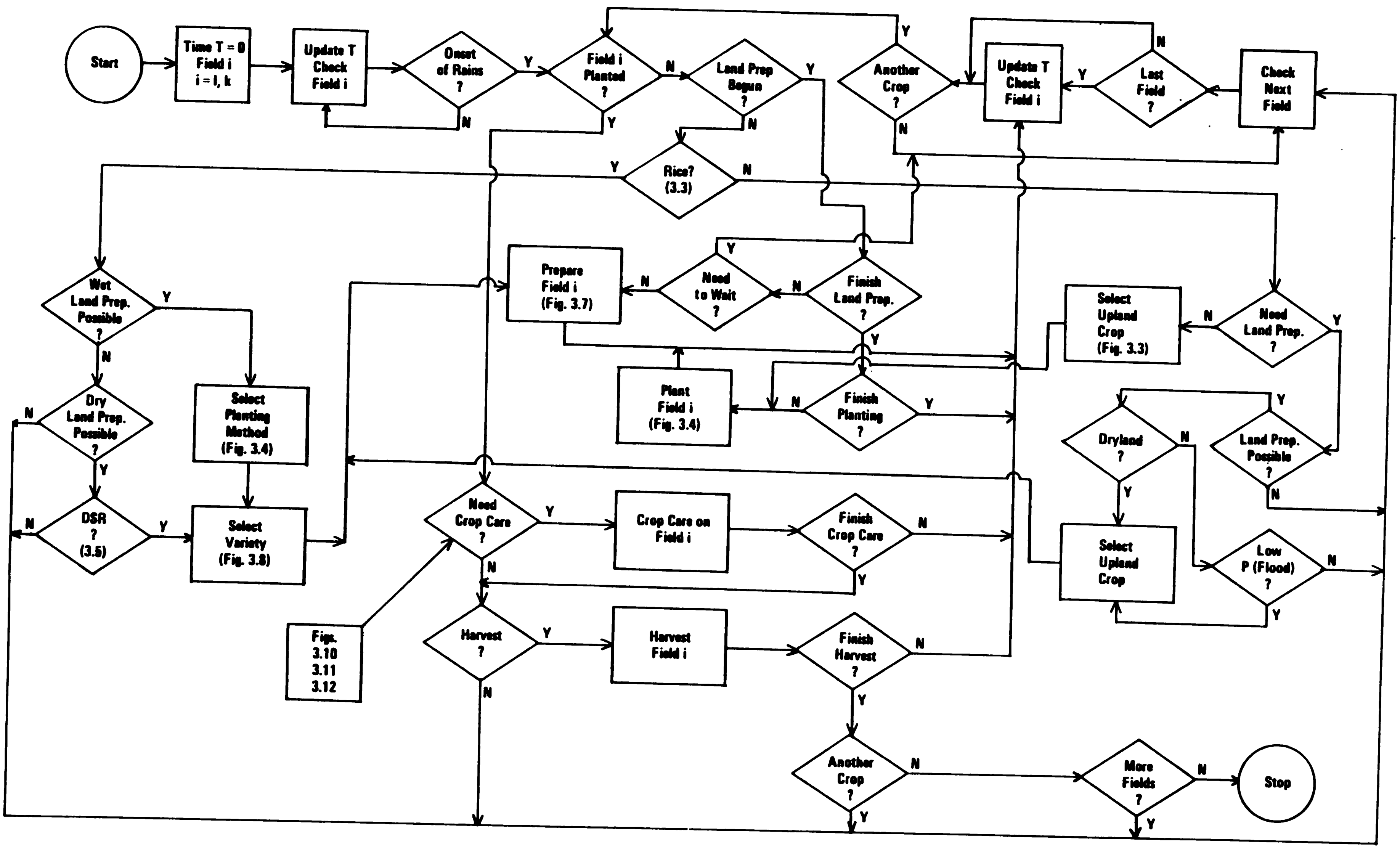

Figure 3.2. Flow Chart of Crop Decision-Making.

According to the model, the farmer checks daily for the onset of the rainfall. If there is no rain, or if conditions are such that land preparation and planting activities are precluded, time is updated representing the waiting time for the beginning of cropping activities. As soon as sufficient moisture is present to warrant consideration of cropping activities, the farmer begins to check the fields. If a field has not already been prepared or planted, the first basic decision point is reached; whether to plant rice or an upland crop.

The crop selection decision is based upon a number of factors, including rainfall expectations, soil structure, and moisture holding capacity of the field. If the farmer expects a gradual onset of the rainy season, with the quantity of rain per period increasing with time, then it is likely that an upland crop could be grown before a rice crop at the beginning of the wet season. It is a common practice in the Iloilo rainfed area to plant green corn before rice on fields which the farmer does not expect to flood before harvest of the corn crop. Even in the higher elevations, however, there exists the danger of crop loss due to flooding should the rainy season begin suddenly with high amounts of precipitation. One response to this situation is the intercropping of rice and corn,[1/] with maximum gain expected in a normal year with a gradual onset of the wet season. In years when rainfall intensity at the beginning of the wet season is low, the corn crop will survive while the rice crop would fail. In years with a sudden, abrupt beginning of the rainy season, the corn would suffer and the rice would flourish.

1/ Not shown in Figure 3.2.

If the decision is made to plant rice on a particular field, the farmer checks as to the type of land preparation possible during the current time period. If sufficient rain has fallen so that the field is thoroughly soaked or flooded, land can be prepared for transplanting (TPR) or wet seeding (WSR) a rice crop. If a field is dry when it is checked, it may still be prepared using dry tillage techniques, though the draft power requirements are greater for tilling dry fields than is the case when the soil is moist or saturated. Land that is prepared during the dry season may be planted to rice by using a dry seeding (DSR) technique. If neither wet nor dry land preparation are feasible or desirable, then other fields are similarly checked. When all fields have been checked and no crop activities are found to be necessary, the process begins again.

If, after checking a field, land preparation is deemed feasible and desirable, the farmer selects the planting method (TPR, WSR or DSR) along with the variety of rice to be used. When land preparation begins, each field is worked for a full time period (1 day). If land preparation on a certain field is incomplete, farmers may still move on to work on other fields. After plowing a field, a waiting period of about one week is common before harrowing. This delay is to allow weed seeds to germinate so that the seedlings will be uprooted during subsequent plowings or harrowings. Tillage may also take place on a field until it is fully prepared. On farms with widely scattered parcels of land, a field may be prepared completely before moving on to others. This is done in order to reduce utilization of human and animal labor for hauling land preparation equipment among widely scattered fields.

Once a field is completely prepared, planting usually takes place immediately, continuing until the field is completely planted. After planting, the farmer checks the field periodically to determine the need for fertilization, weeding or elimination of destructive insects. If none of these activities are necessary, and the field is not ready for harvest, the farmer moves on to check other fields and carry out other activities when necessary. When the harvest of a given field is completed, a decision is needed as to whether or not it will be possible to plant another crop on the field. If there is no possibility of establishing another crop, the field is dropped from consideration. When all fields have been harvested, and no new crops are feasible on any field for the current season, cropping activity on the farm ceases.

If an upland crop is chosen rather than rice, the farmer's decisions are basically similar except in a few aspects. First, land preparation is not always a prerequisite to the planting of an upland crop. For example, Iloilo farmers commonly broadcast mungbean or cowpea seeds into the stubble of a harvested rice crop as soon as field hydrologic conditions permit. In such cases, an upland crop is selected and planted without prior preparation of the field. If land preparation prior to planting an upland crop is necessary, the field is checked for preparation feasibility. If the soil is sufficiently moist so that a plow can pass easily, land preparation can begin. If the field to be prepared is located in hilly or unbunded areas (dryland complex), flooding danger is low and preparation can begin immediately after crop selection. The possibility of flooding, resulting in upland crop damage or loss, exists to a greater degree on flat or bunded sideslope areas. Within these areas, the likelihood of flooding is determined by soil texture and water table depth. A farmer may not know the depth of the water table or the exact composition of the soil, but he has learned through observation whether or not his field will flood, given an expected amount of rainfall. If, in the farmer's estimation, the probability of severe crop damage or loss due to excessive moisture conditions is low, an upland crop can be selected and planted on the field, either before or after a rice crop. Once the decision to plant an upland crop is made, land is prepared if necessary and basic activities are carried out which are similar to those for a rice crop.

Models of Specific Decisions

This section describes the basic activities and decisions of rainfed farmers in Iloilo. Greater insight into what is happening and why can be obtained by examining certain specific activities and decisions more closely.

Crop selection decision

At the beginning of a cropping season, the key factors which affect the crop selection decision are current soil moisture (at the time of the decision), and the likely moisture status of the soil during crop growth. As indicated in Figure 3.3, a farmer can choose to plant an upland crop on a paddy field if he believes that the probability of flooding, resulting in crop damage or loss, is sufficiently low to warrant taking a risk. Therefore, the farmer's subjective knowledge about the characteristics of a particular field (i.e. moisture retention capacity, drainability and fertility) and his subjective rainfall expectations influence the cropping decision.

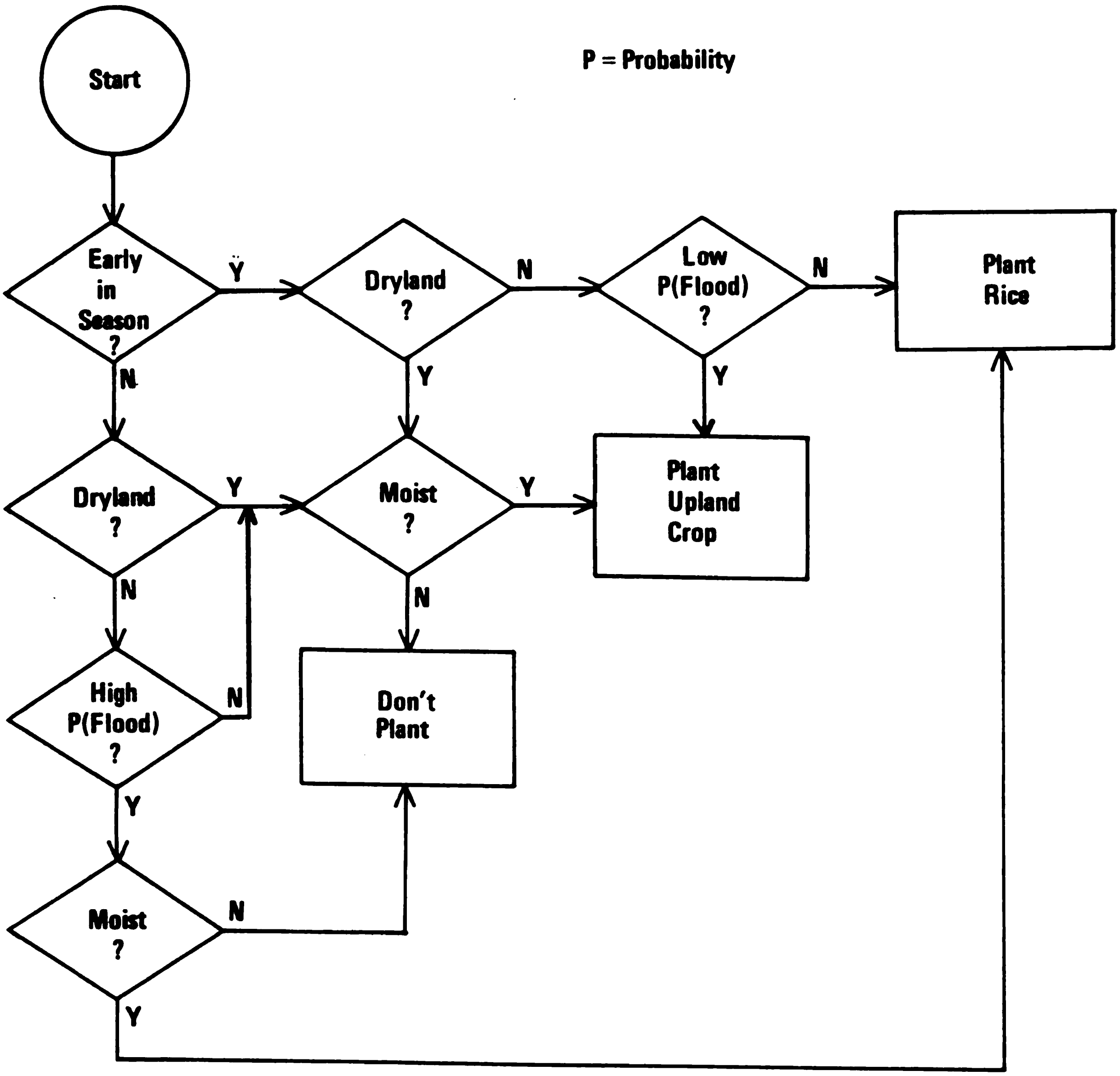

Figure 3.3. Flow Chart of the Crop Selection Decision.

If the crop to be selected and planted is the first of the current planting season, two elements are checked. The first is landscape position. If the field position is classified as dryland complex, no rice will be planted. The main consideration is whether an upland crop can grow under current and expected future soil moisture conditions. On fields where rice is normally planted during at least part of the growing season, the possibility exists of planting an upland crop early in the season if a gradual onset of rainfall is expected and the characteristics of the field are such that the probability of substantial flooding during the growth of the upland crop is at a tolerably low level. If a field is likely to flood before an upland crop can be harvested, it will be planted to rice as a first crop as soon as moisture is sufficient for land preparation and planting.

In Iloilo, corn is the most common upland crop grown on rice lands at the beginning of the growing season. It is usually planted on side slopes and high plateau areas with coarse-textured, well-drained soils. Land preparation for the corn crop is minimal, limited mainly to making furrows and seeding. The stage at which the corn is harvested is dependent upon the rainfall and subsequent field moisture conditions. If fields begin to flood earlier than expected before ripening is complete, the corn plants are cut and stored for animal feed. If the rainfall pattern is as expected, most of the corn will develop ears, which are harvested green and used for both human and animal food. In cases where heavy rains begin extremely late in the season, the corn may be allowed to ripen on the stalk.

The selection criteria for crops planted from the middle to the latter stages of the growing season are similar to those utilized for the choice of an early season crop. However, the possibility of losses due to drought stress become as important as losses due to flooding. If the field is to be planted well before the termination of heavy rains so that there is still a large probability that flooding will occur, the option of planting an upland crop is eliminated at least for the time being. If, in the farmer's judgment, the field will be supplied with sufficient moisture to support a rice crop, he would choose to plant rice.

If further flooding is unlikely, and sufficient moisture is expected which will sustain an upland crop, the field can be planted with an upland crop. If expected moisture conditions are poor, the field will not be planted until the next season.

Once a crop has been selected, decisions then need to be made regarding land preparation and planting techniques and agronomic management practices. The decisions a farmer must face from the time of land preparation until after the crop is harvested vary with the type of crop selected. Rice will be considered here.

Preparing and planting a rice crop

Planting method selection. In the Iloilo area, there are three distinct methods of establishing rice crops. The most common method of crop establishment in Iloilo is called wet seeding (WSR), or broadcasting pre-germinated rice seeds onto puddled, flooded soil. Another common establishment method is transplanting (TPR), which consists of growing seedlings in a seedbed until they have reached sufficient height to [illegible] planted onto [illegible] puddled or flooded paddy field. The third method, dry seeding (DSR), involves the planting of ungerminated seeds in dry soil. The dry seeding technique was a common practice in Iloilo as far back as the early 1900's (Price, 1976). Due to severe problems with weeds, and the availability of an abundant supply of labor, transplanting gradually replaced dry seeding as the dominant rice crop establishment technique. DSR was recently been re-introduced in the area by the IRRI CSP along with the early maturing varieties (EMVs) in order to facilitate multiple rice cropping in the rainfed areas. WSR as an establishment technique is relatively new to the area, gaining acceptance concurrent to the introduction of the EMVs.

The farmer first checks the possibility of preparing land for WSR or TPR (Figure 3.4). Wet land preparation is possible when paddy field soil becomes thoroughly soaked from rainfall and drainage from fields higher in the topographical sequence. If wet land preparation is possible, then four criteria are checked in order to determine whether the crop will be wet seeded or transplanted. All of the criteria were expressed by farmers during interviews, though no single farmer cited all the criteria as important.

The most commonly cited criterion was that of expected yield. The transplating method of crop establishment was originally adopted by farmers because they could obtain higher yields than with dry seeding, mainly due to the seedlings' favorable competitive position with respect to weeds. A farmer would not likely want to incur the extra cost of transplanting unless an increase in yield is expected. Therefore, if no yield increase is expected, WSR would be chosen because of its lower cost. If, however, the expected yield for TPR is greater than for WSR,

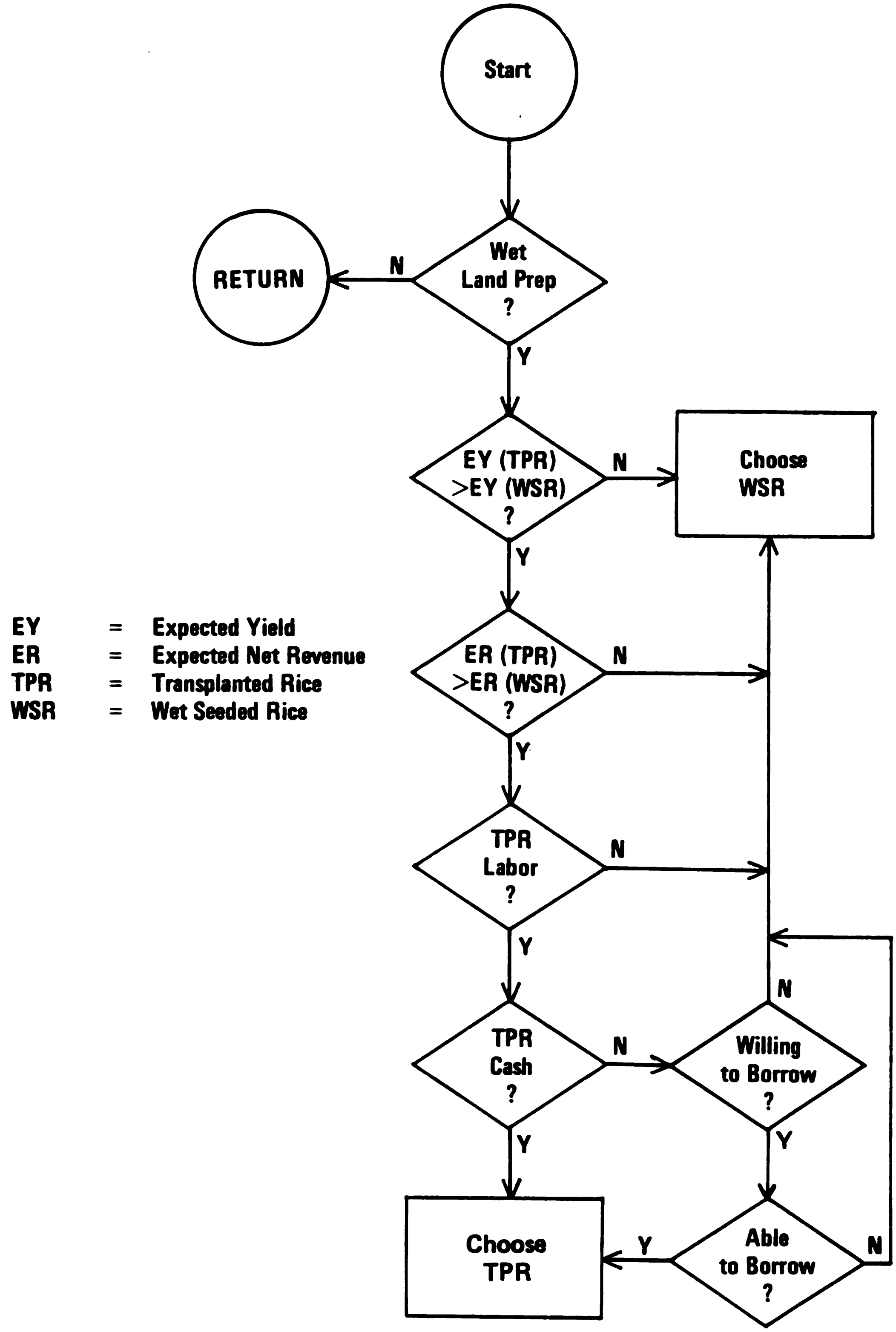

Figure 3.4. Flow Chart of the Wet Planting Method Decision.

a criterion of degree is encountered. This criterion is expressed in terms of expected gross margin. TPR may be chosen only if the expected value of the extra yield from TPR exceeds the extra costs of the method. If not, WSR is chosen.

If TPR is chosen, a labor availability criterion must be met. Transplanting is an arduous task which must be completed in a relatively short period of time. Except on the smallest farms, family labor is inadequate for transplanting. Therefore, labor must be hired within the community, and TPR can be chosen only if there are sufficient workers willing to transplant at the prevailing wage. If for some reason labor is not available, then WSR will be chosen. If labor is available at the prevailing wage, cash availability becomes important. Of the cash that a farmer has on hand to purchase productive resources, is there a sufficient amount to hire TPR labor? Given that farm resources are limited, the farmer must decide what is the best use for each resource. If cash on hand is not sufficient to cover transplanting costs, the farmer may be willing to borrow if the expected extra return will more than cover the interest cost, if the farmer believes that cash invested in transplanting is the best alternative use for cash, and if the farmer's self-imposed or externally imposed borrowing limits have not been reached. If a farmer is willing and able to borrow for TPR, or has sufficient cash on hand available for that purpose, then he would choose to transplant. Otherwise, WSR would be chosen.

If the soil in a paddy field is not soaked early in the wet season, the possibility of dry land preparation and seeding arises (Figure 3.5).

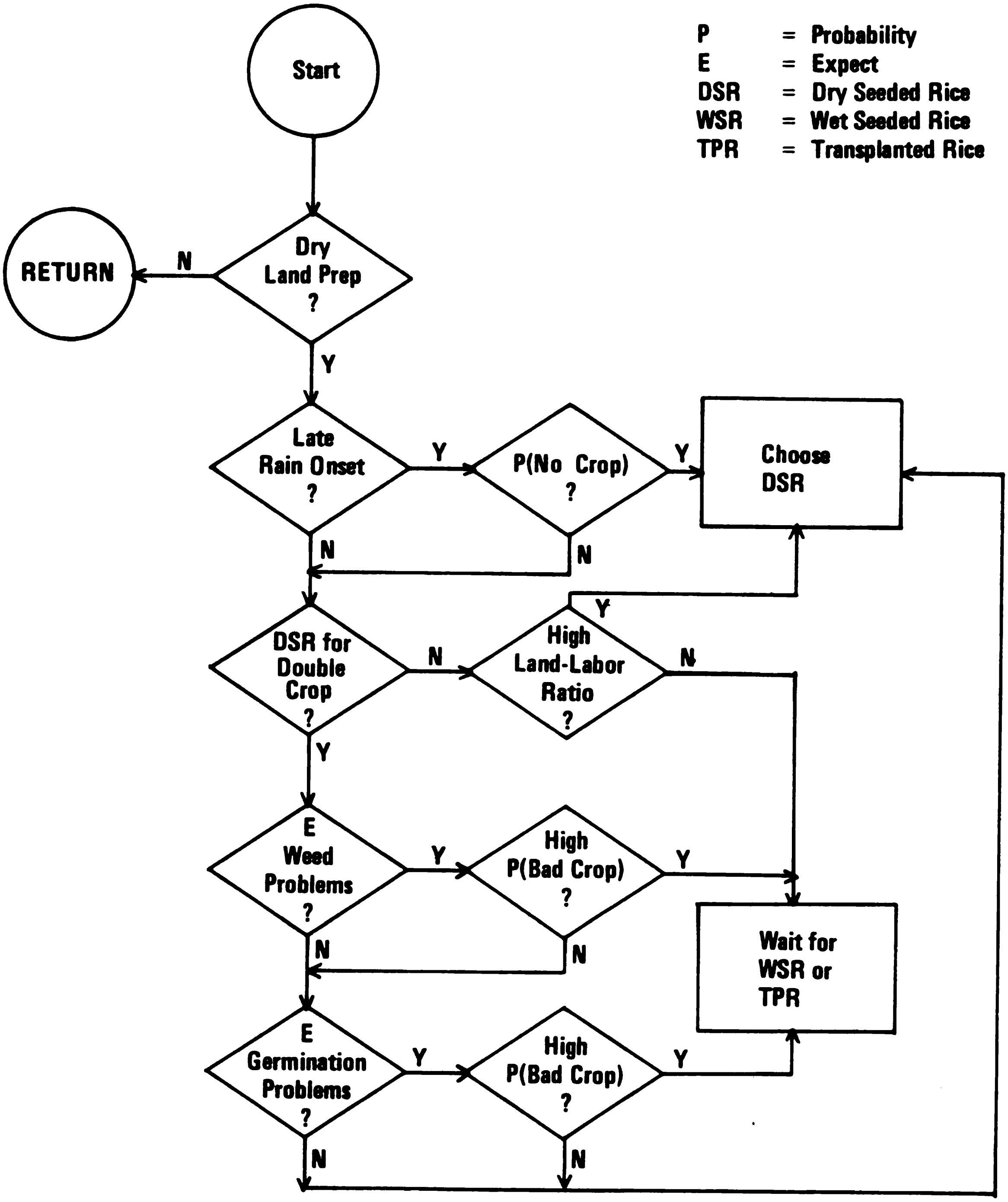

Figure 3.5. Flow Chart of the Decision to Dry Seed.

If the beginning of the wet season is late, such that the farmer suspects danger to the first rice crop through drought stress due to rainfall termination (short wet season), DSR may be chosen. If the onset of the wet season is not late, it may still be desirable to utilize the DSR establishment method in order to plant the wet season rice crop early in order to have the opportunity to plant and harvest a second rice crop before the complete cessation of the rains.

The problems with DSR encountered since the early 1900's still plague Iloilo farmers today. If a farmer expects that the problems with weeds will be severe enough to make the probability of a poor first crop unacceptably high, it is unlikely that he would choose DSR to establish his first rice crop on a very large part of his farm. Even if weed problems do not seem insurmountable, there also exists a problem with uneven or poor germination, resulting in non-uniform maturation dates. If neither weed problems nor germination problems appear serious, DSR would be chosen.

Even if DSR is not a prerequisite to double rice cropping, it may still be practiced on farms with a high land/labor ratio. The land preparation operation is normally carried out by the (male) head of the family, with a complementary draft power source (carabao). DSR enables the spreading out of land preparation labor over a longer period of time, since rice may be dry seeded before the rains are sufficient to thoroughly soak the fields.

Recent trends in farmers' selection of crop establishment technique are depicted in Figure 3.6. As late as 1976, transplanting was still the

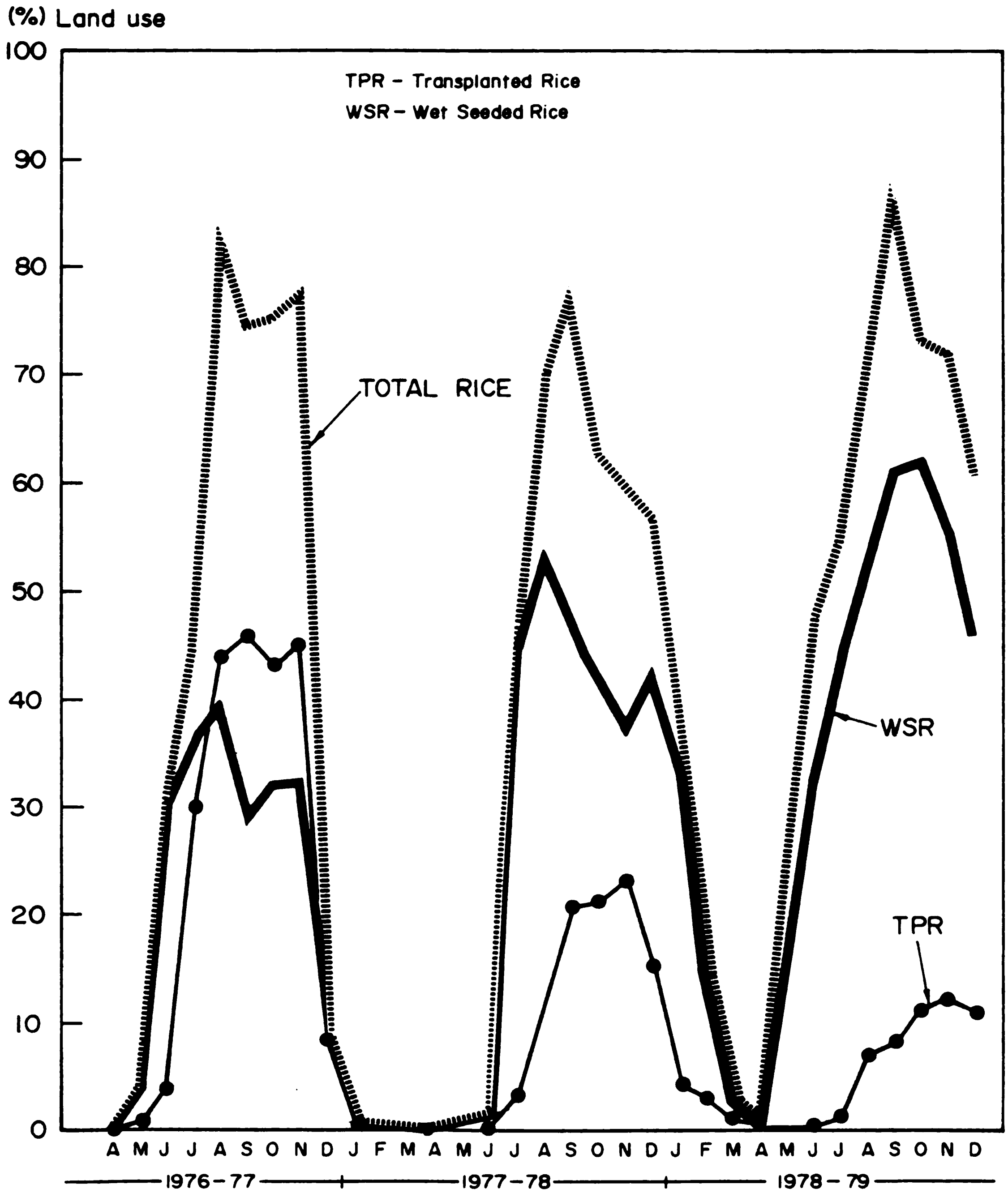

Figure 3.6. Percentage of land utilization by method of rice crop establishment, Iloilo, 1976-1979.

most common rice crop establishment method. Since tnen, however, wet seeding has increased in popularity, due to its reduced cost and increased flexibility. For TPR, farmers must calculate in advance the date fields will be ready for transplanting. Therefore, farmers often wait until sufficient rainfall has occurred in order to be sure that fields will be ready for transplanting when the seedlings have reached their proper age. There also may be problems in procuring transplanting labor at the time it is desired. Given this situation, it is possible to appreciate why farmers are adopting WSR.

Land preparation. Decisions related to the process of field preparation for planting rice or upland crops are schematically outlined in Figure 3.7. At this point, the decision has been made regarding the crop to plant and the planting method to be employed. The choice of crop largely determines whether land preparation is necessary. If no land preparation has yet taken place, the field is first plowed, and a check is made as to whether harrowing is necessary. If so, the field is harrowed. If a wet paddy field is being prepared for transplanting or wet seeding rice, weeds are controlled during land preparation. Farmers generally wait at least a week after the first plowing and harrowing to allow weed seeds to germinate. Successive harrowings uproot weed seedlings, so that the rice crop may be established under relatively weedfree conditions. Once sufficient harrowing has been done to control weeds, paddy fields can be leveled if necessary. Otherwise, the field is ready for planting after the last harrowing. Land preparation operations for the dry seeding of rice are similar to those employed for wet crop establishment

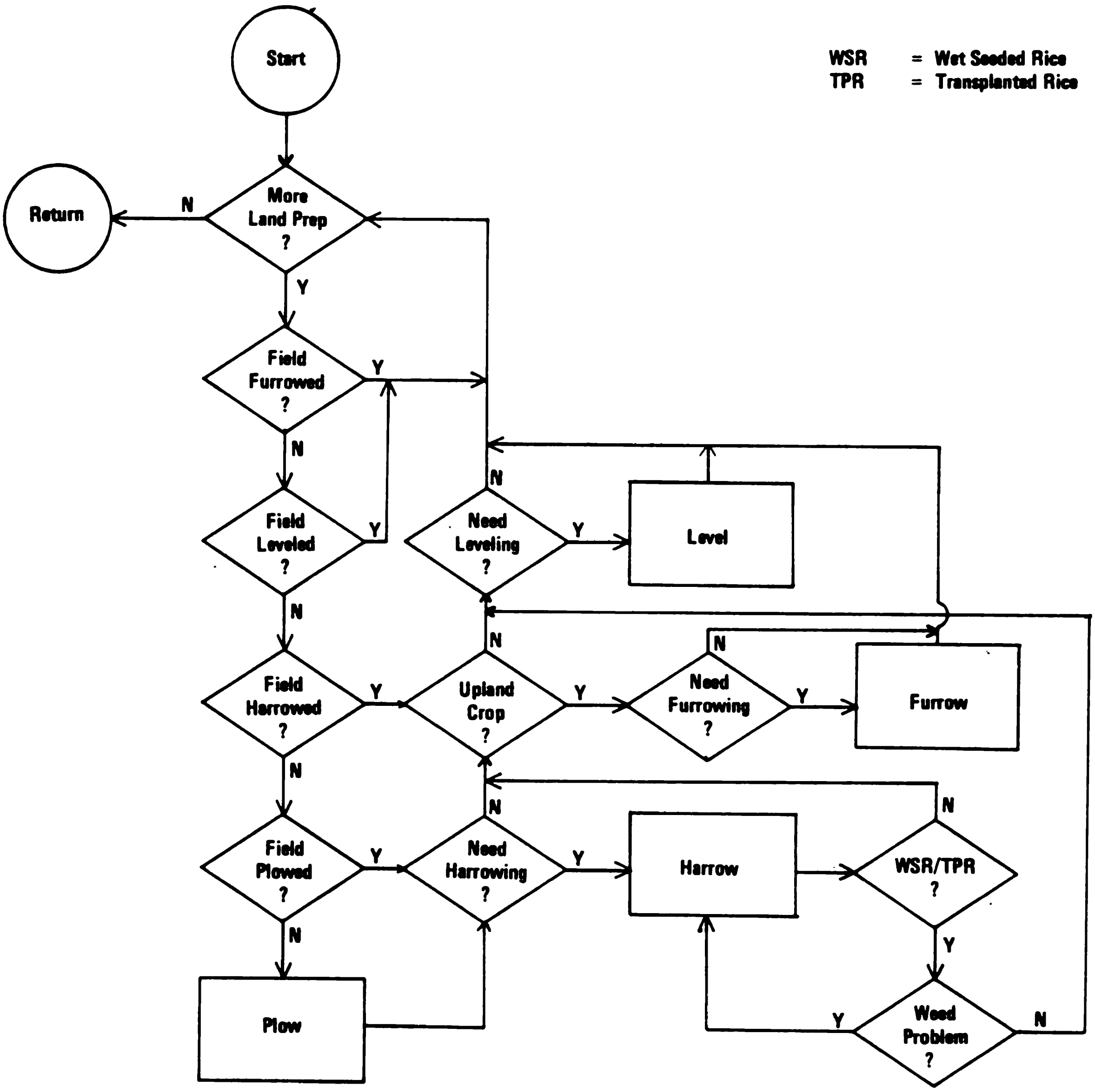

Figure 3.7. Flow Chart of the Land Preparation Decision.

with the exception of weed control. Since the land is being tilled dry, sufficient moisture may not be present to promote the rapid germination and growth of weed seedlings. Therefore, dry land preparation is not an effective means of weed control.

For upland crops, such as corn, furrowing is the last stage in the land preparation process. Furrowing involves the creation of small trenches in a field for row planting of upland crops. Furrows facilitate the channeling of water to crop root systems. For tall-growing upland crops, such as corn, the furrows may be closed after the seedlings have exceeded ground level, in order to provide extra support for the plants as they grow. This activity, called "hilling up", helps prevent lodging.

Varietal selection. At some point prior to the actual planting of a rice crop, a decision must be made as to the variety to be planted (Figure 3.8). The decision criteria expressed by Iloilo farmers reflect multiple objectives. The first criterion appears to be yield. In choosing between modern and traditional rice varieties, preference is given to the variety which produces the highest expected yield per unit of planted area. If, for a given field, a farmer expects a higher yield from a local variety than from an early maturing variety, the issue of multiple cropping becomes important. If it is not possible to plant more than one crop on a field during a cropping season, a local variety would most likely be chosen. However, if it is possible to grow two crops of rice during a season, or rice followed by an upland crop, further consideration is necessary. If the expected benefits of a modern variety in a multiple cropping scheme exceed those of a single cropped local variety, then further criteria must be examined before a choice can be made.

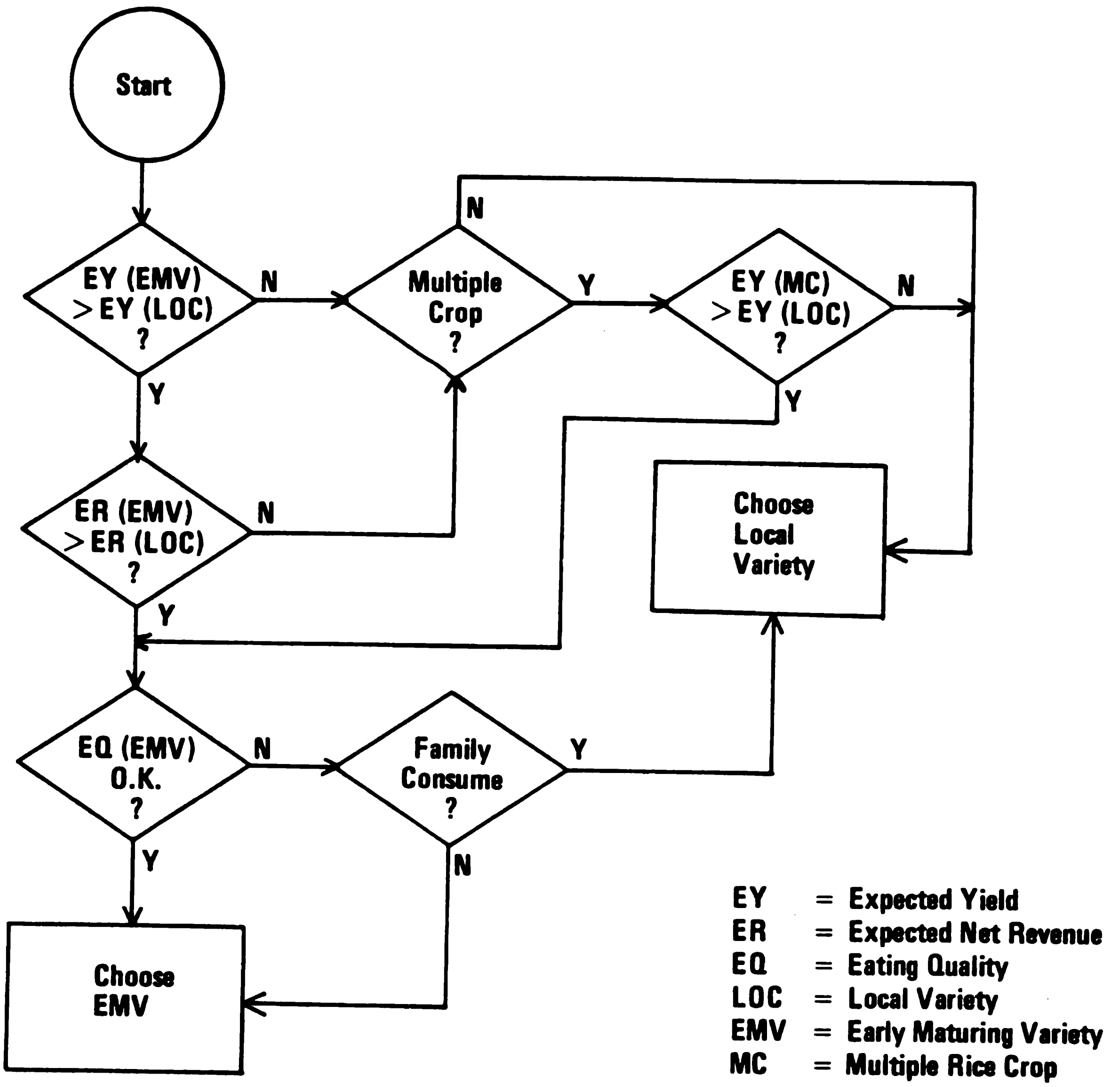

Figure 3.8. Flow Chart of the Varietal Selection Decision.

Another important selection criterion is that of profitability. Although a modern variety may out-yield a traditional variety, benefits cannot be examined strictly by evaluating yields if costs differ. If the value of the extra inputs needed to support modern varieties is greater than the value of the extra yield, then the traditional variety taken as a single crop is more profitable. In such a case, the possibilities for multiple cropping must be examined.

If the expected net returns of an EMV are greater than those of a traditional variety, a check is made on the eating quality of the new variety. If it is acceptable, the EMV will be chosen for planting. If it is not acceptable, and the crop is for family consumption, then a local variety may be chosen. If the rice is to be sold rather than consumed by the family, the profitability criterion would determine the selection of the variety.

An indication of the varietal adoption response of farmers in the Iloilo rainfed area is given in Figure 3.9. The adoption of early maturing varieties has increased notably during the 1977-78 and 1978-79 cropping seasons. In 1977, a maximum of 35% of the total area planted to rice was planted with early maturing varieties. In 1978, planting of EMVs reached 60% of total area planted to rice. In general, EMVs are established early in the year on fields with a high multiple cropping potential, followed by traditional varieties established later in the season when multiple cropping potential has diminished. Information regarding average yields and average net returns for modern and traditional rice varieties is presented in Table 3.1. Except for second rice

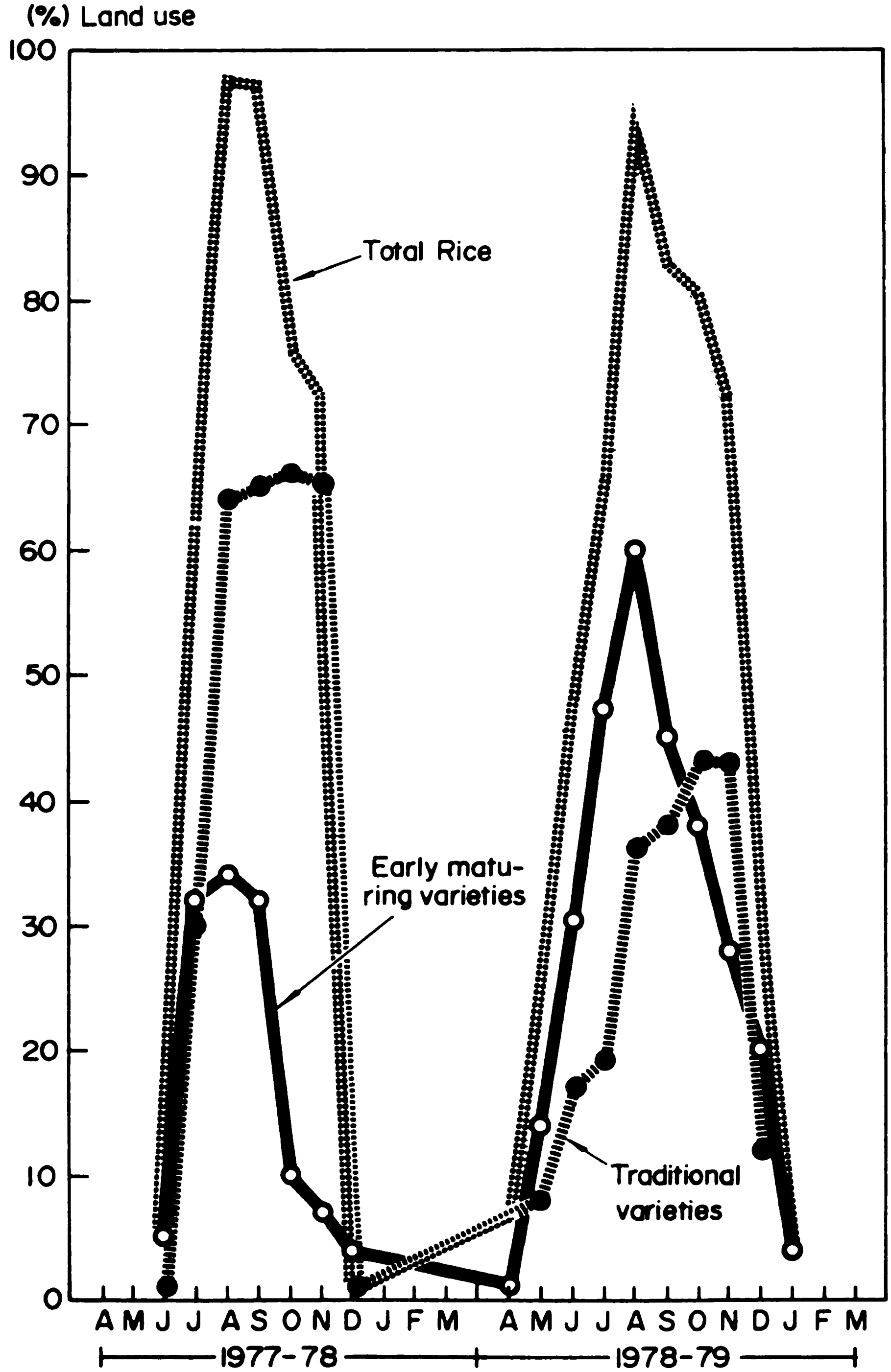

Figure 3.9. Trends in adoption of early maturing rice varieties in Iloilo, rainfed areas, 1977-1979.

crops planted in 1977-78, both average yields and average net returns for EMVs exceeded those for traditional varieties. This helps to explain the increased incidence of adoption of EMvs demonstrated in Figure 3.9.

Most farmers state that the eating quality of EMVs such as IR36 approximates that of the traditional varieties. Some farmers, however,

Table 3.1. Comparison of average yields and net returns for rainfed rice crops in Iloilo, 1977-79.

	1977-78		1978-79	
	Av. yield (kg/ha)	Av. net return (P/ha)[a/]	Av. yield (kg/ha)	Av.net return (P/ha)
		Early maturing varieties		
First crop	2418 (20)	1416	2164 (21)	1022
Second crop	411 (6)	-87	2525 (16)	1202
		Traditional varieties		
First crop	1805 (21)	966	1789 (18)	621
Second crop	1132 (7)	268	1854 (5)	779

Number of observations in parentheses.

a/ P 8.8 = US$ 1.0

Source: Compiled by author.

grow traditional varieties on parts of their farm for home consumption. This is especially true for glutinous rice, which is used mainly in the preparation of snack foods and desserts.

Crop management decisions

Once choices have been made as to crop establishment and land preparation techniques, and the crop has been established, each field is periodically examined for incidence of pests or diseases, weeds, and nutrient deficiency.

Fertilizer application. The amount of fertilizer a farmer uses is a function of his previous experience with fertilizer and his current cash and credit situation. The first criterion of fertilizer use is profitability. A farmer will use fertilizer if the value of the expected yield more than covers the cost of fertilizer. Since fertilizer must be applied to a crop at an early stage, decisions regarding fertilizer use are made under a great deal of uncertainty. Therefore, splitting the quantity of fertilizer allocated to a particular field into two or three applications is a common practice. The first application is applied at seeding, or shortly thereafter. Later applications come a month or two after planting, when the farmer feels reasonably sure that added fertilizer will obtain its desired effect. Many farmers mix their fertilizers, the most common being a blend of 16-20-0 and urea (45-0-0). Some farmers claim that the amount of fertilizer applied to a field is the same, regardless of the variety planted. Others, however, say they have learned that the modern varieties perform better with higher quantities of fertilizer, and thus apply slightly higher amounts to those fields planted to EMVs.

A diagram of the fertilizer decision process is presented in Figure 3.10. If sufficient fertilizer is already in the farmer's possession, it can be applied when necessary. If insufficient fertilizer is on hand, cash can be used to purchase additional quantities. If cash is insufficient, a farmer may be willing to borrow if he believes that the return from the fertilizer borrowed will more than compensate the cost of the fertilizer plus the interest charge on the loan. Small farmers, however, often face both internally and externally imposed credit restrictions which affect borrowing for input purchases. Therefore, a farmer may be willing to borrow for additional amounts of fertilizer, but be unable to obtain the necessary credit. If credit is available and the farmer is willing to borrow, then he can obtain and use fertilizer.

Pest management. Prophylactic or preventative pest control measures are not common in the Iloilo rainfed areas. As specified in Appendix B, insects do not normally cause great damage to rice crops planted at the beginning of a cropping season after a fallow dry period. Farmers generally wait until pests are visible before considering the application of insecticides (Figure 3.11). If insects are visible, but little or no damage is expected, no action will be taken. If a farmer considers that damage is likely, he then must evaluate the usefulness of pesticide application with respect to cost and expected benefits. If he decides that the expected benefits, in terms of reduced loss of yield and

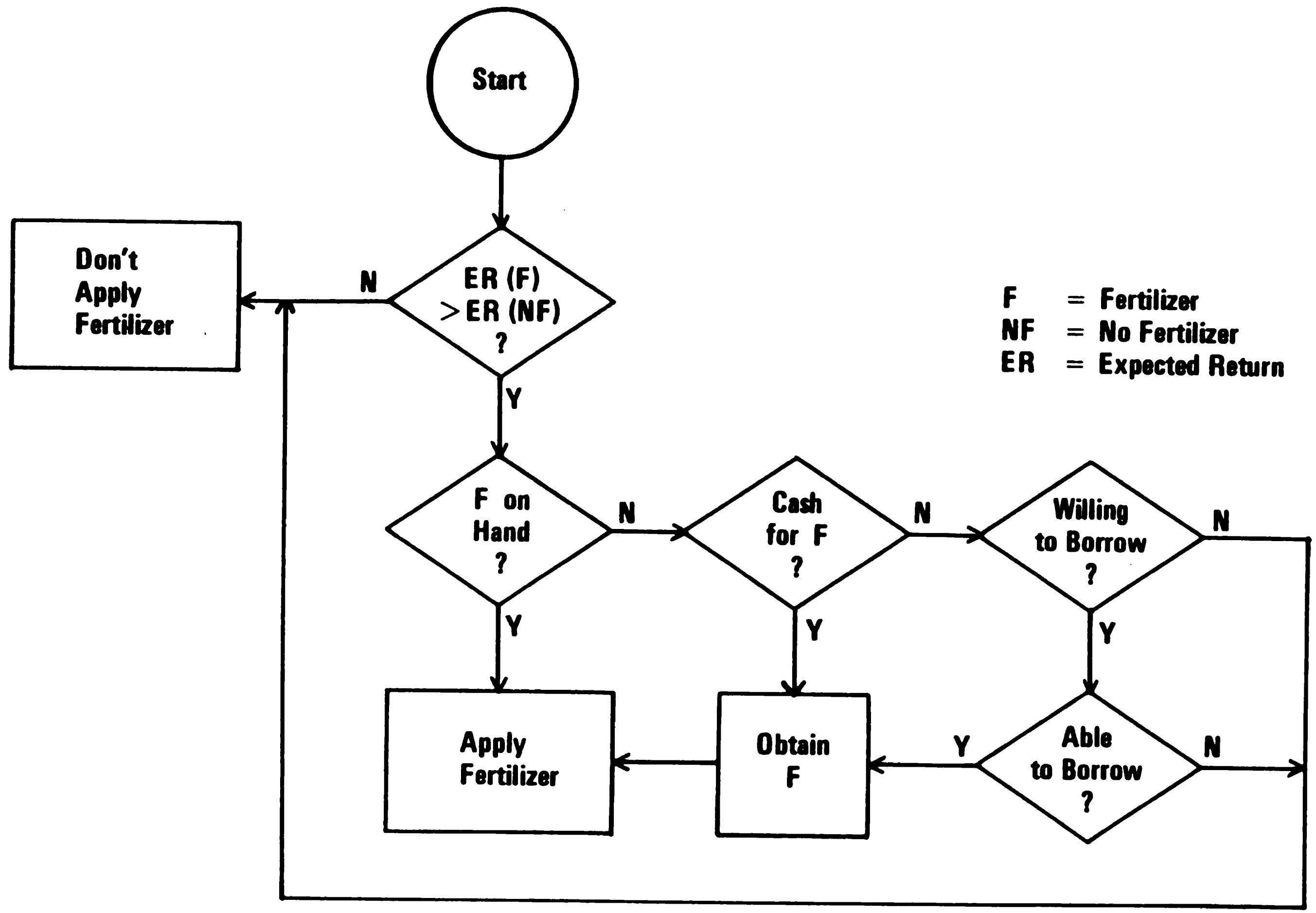

Figure 3.10. Flow Chart of the Fertilizer Application Decision.

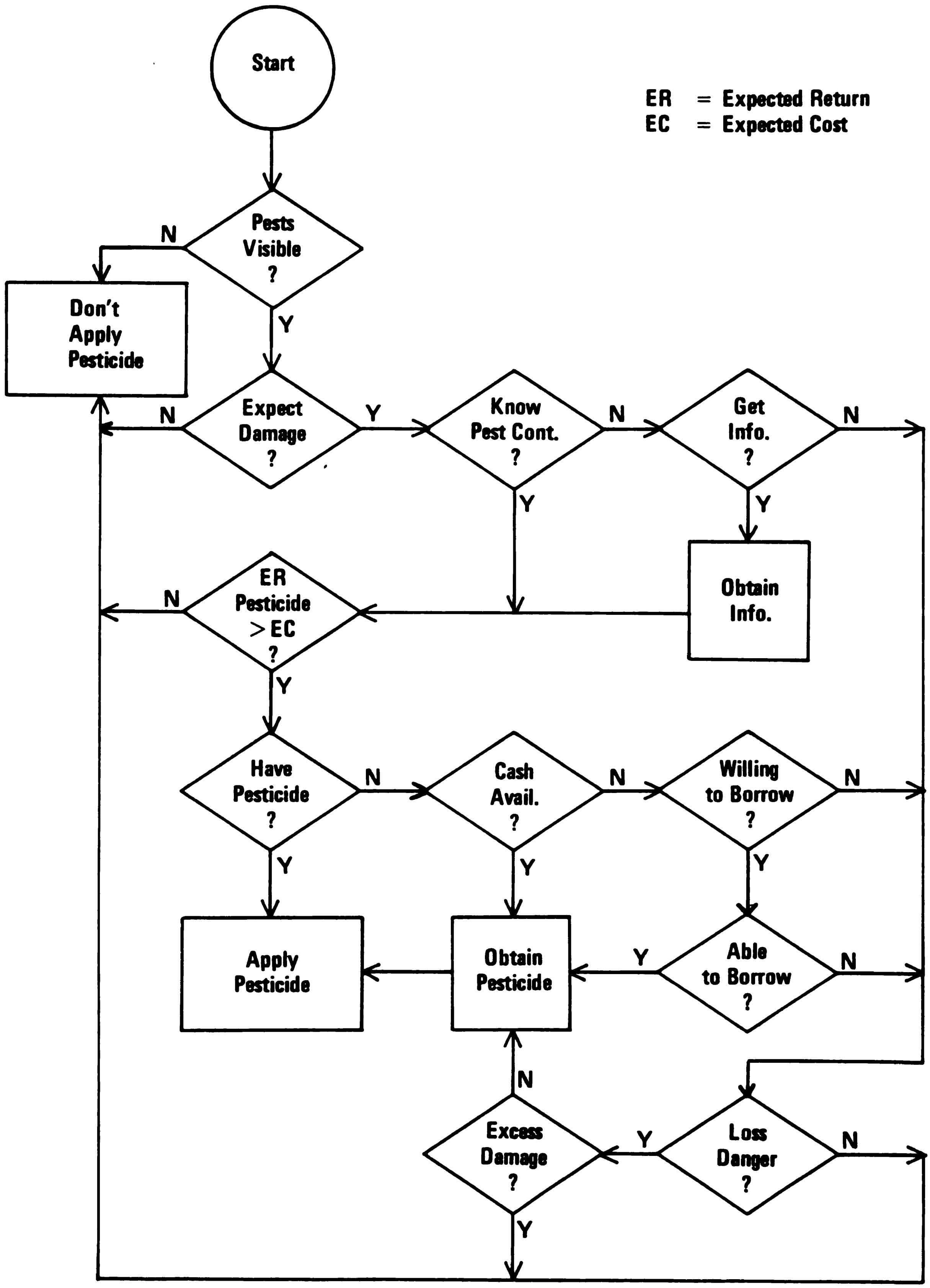

Figure 3.11. Flow Chart of the Decision to Apply Pesticide.

income, do not outweigh the costs of pesticide application, a decision to apply pesticide in unlikely. If benefits do outweight costs, then pesticide will be applied if the farmer has sufficient amounts of the appropriate chemical on hand. If not, a check is made as to whether sufficient cash is on hand for pesticide purchase. If not, the farmer may be willing to borrow in order to obtain pesticides. If the farmer feels that the benefits of fertilizer are greater than those of pesticide, he will increase his supply of fertilizer at the expense of a reduction in pesticide use. The reverse would be true if the expected contribution of pesticides is greater than that of fertilizer. If cash and credit limits are not reached, the farmer may be willing and able to borrow for pesticide purchases. In such a case, he will obtain and apply pesticide. If an insect attack has reached the point of danger of a total crop loss, the farmer will try to control the danger by applying pesticide provided that the danger is not such that crop failure is imminent regardless of any corrective action.

Weed management. Land preparation before a crop is planted is the most commonly employed method of weed control in the Iloilo area. However, should sufficient weed growth occur to cause the farmer to believe that a yield reduction would result if a field is not weeded, consideration of a weed control method would take place. Handweeding, using family labor, is the most common weed control practice after a crop has been established. If family labor for weeding is unavailable, the farmer may use cash on hand or may borrow to hire labor if the expected value of handweeding in terms of increased value of the harvest more than compensates for the cost of the weeding process (Figure 3.12).

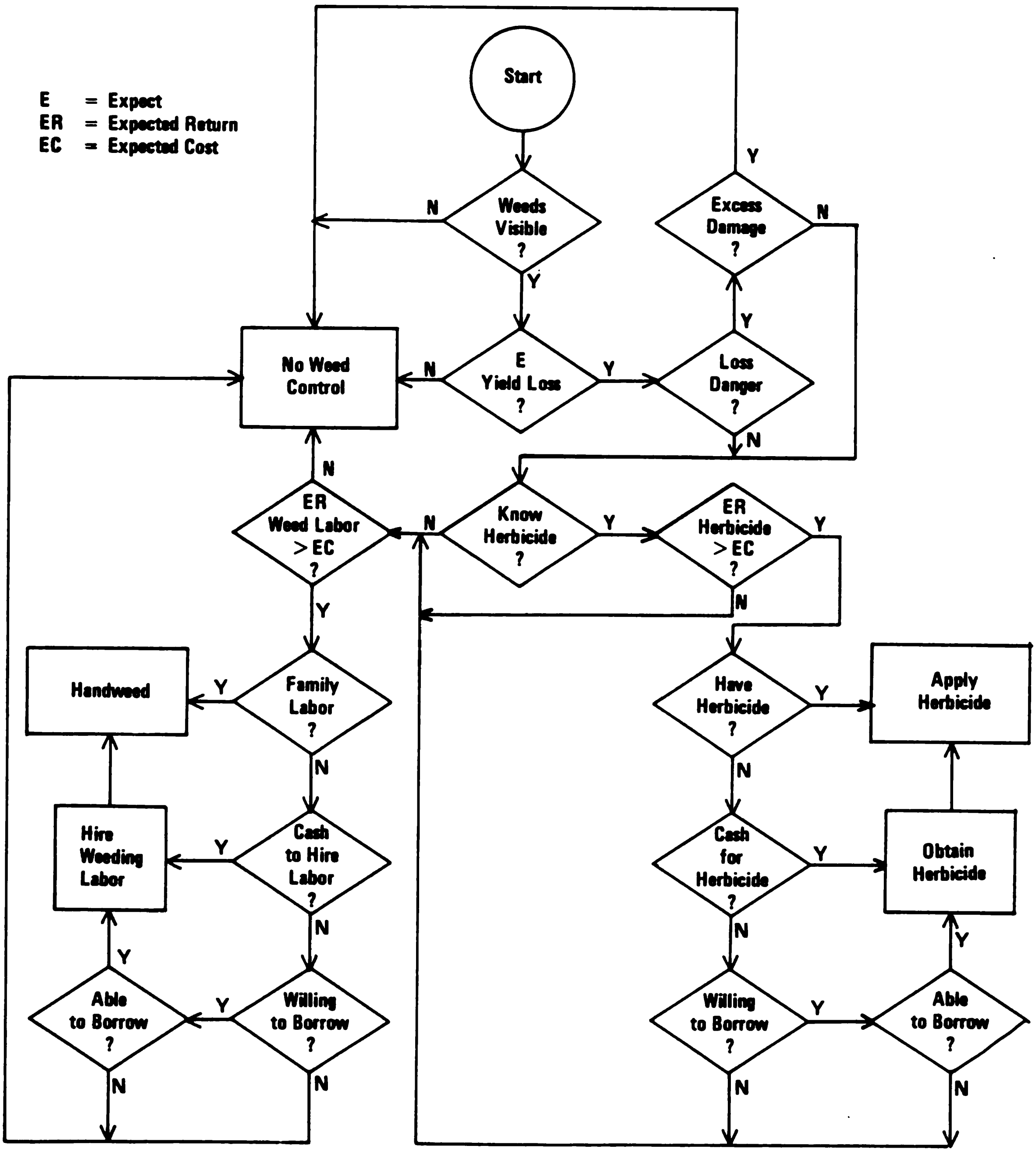

Figure 3.12. Flow Chart of the Weed Control Decision.

Herbicide is another option for weed control. Herbicides are rarely used in Iloilo, and little is known by farmers about their use and effectiveness. When questioned about herbicide use, most farmers expressed a fear that herbicides would kill their crops as well as the weeds. Two farmers cited specific instances where this had happened. If a farmer has knowledge of chemical weed control and decides that the use of herbicide is his best alternative, then he will apply herbicide if he has it on hand. If not, the farmer must decide whether to allocate cash to the purchase of herbicide or whether to borrow to obtain the needed input. These decisions again depend upon whether the expected increase of the value of the output will more than cover the cost incurred in obtaining and applying herbicide.

In case there is danger of a crop failure due to excess weed competition, a farmer may take special measures such as allocating extra labor, cash or credit resources. If, however, the damage appears beyond repair, no further investments will be made on the crop.

With the descriptive conceptual model as background, a qualitative view of rice farming in Iloilo is now presented.

CHAPTER 4

A QUALITATIVE VIEW OF FARMING IN ILOILO: EXPERIENCES OF THE UMERO FAMILY

The purpose of this chapter is to put the conceptual model described in Chapter 3 in a specific context so that a qualitative understanding can be achieved of the socioeconomic, agroclimatic and biological environments and their influence on Iloilo farmers' production decisions. The narrative is based upon the situation and experience of an actual farm family. However, since there is a great deal of heterogeneity among farms even within a small geographic area, not all of the experiences described happened to all farmers, nor did they all happen to any one farmer. What is presented, then, is the description of a composite farm which illustrates the conditions and problems which small farmers face, and their typical reactions.

The Family and Their Situation

Jose Umero lives with his wife Elena and their children in a small nipa hut near their one hectare farm in a small village in Iloilo province. The Umeros are young (age 35), and have two sons who are too small to handle work in the fields.

The land that the Umeros farm is not irrigated, so they must depend upon rainfall to provide sufficient moisture to grow their crops. About one-half of their land is sloped, with light-textured soil, so that the soil quickly loses moisture when the rains stop even though the field is divided into level portions and bunded. The other half is flat land, just below the sloped portion, with heavier soil and better moisture retention capacity. Ordinarily, the flat land floods first because of its heavy-textured soil and because it also receives water which runs off the slope. The flat land, however, is not immune to water loss, as it too permits water to seep down to nearby fields which are lower.

The Umeros do not own the land they farm, but rent it on a harvest share basis. The landlord receives one-third of the output, net of harvesters' share, as payment for the use of the land. In a good year (high rice yield), the share of the crop the Umeros receive is enough to meet their family rice consumption needs, repay debts and provide seed for the next planting, with a little extra to sell in order to buy family consumption items. In a bad year (low rice yield), the Umeros cannot even harvest enough for their own consumption, and must rely upon relatives and friends who have a bit of surplus to lend them the items they need to subsist until the next harvest.

The results of one year influence to some extent the cropping decisions that Jose makes the following year. After a bad year, Jose is pessimistic. The family has little money, and they have accumulated debts which need to be repaid. Since crop losses are mainly due to drought, Jose is hesitant to go deeper into debt borrowing for fertilizer for fear that his investment will be lost if severe drought occurs. On the other hand, after a good harvest, Jose becomes more optimistic because he has enough to feed his family and pay off at least part of his debts. He becomes more willing to try different approaches to farming, such as trying new varieties or adding more fertilizer. Because he is cautious, however, he normally tries something different on only a small portion of his land at first in order to see for himself the value of the new approach.

Since the Umeros began farming in 1963, their usual cropping system was based upon one rice crop followed by an upland crop or fallow. Until 1976, the rice Jose planted was of the traditional type; tall, late maturing and often plagued by insects and diseases. The varieties that gained greatest acceptance in the area were chosen as much for their eating quality as their yielding ability, since the yield of most varieties was much the same.

In the early 1970's the Umeros learned of a new type of rice, sometimes called "miracle rice," which did not grow as tall, was resistant to pests and diseases, and produced high yields. Jose was given some seed by the local extension agent. He was told that he must apply large amounts of fertilizer so the plant would grow and produce well, use herbicide to control weeds, and use insecticide to kill insects, even when he could not see them. Jose knew from the beginning that he could not afford to by all the materials in order to do what the extension agent was suggesting. Nevertheless, he accepted the seed and chose to plant it in one of his better bunded fields. He decided to treat the new rice just as he did the local varieties.

He sowed the new rice into a seed bed. The extension agent suggested that the miracle rice should be transplanted between 15 and 25 days after seeding. However, when that time arrived, the seedlings were too small and delicate. So, Jose waited until they were tall enough, about 40 days after seeding. Unfortunately, a typhoon came that was quite strong and blew the roof off his house. This event delayed transplanting still further.

After transplanting, the Umeros kept a careful watch on the progress of their new rice, with anxious expectation of a bountiful harvest. From time to time while the crop was growing, Jose noticed tiny brown insects on the leaves of some of the plants. Surely these insects could not be causing trouble, since they were so small and did not appear to be doing much damage. He did, however, notice that some plants appeared to be much smaller than others. Jose thought that surely the seed that the extension agent had given him had a mixture of at least two varieties. The seed people from the government were always doing that. That is why he preferred to save some of the grain from the previous harvest to use as seed for the next year's crop. Besides, it was cheaper and he did not have to go into debt to obtain seed.

What really worried Jose was the fact that the plants were not producing many tillers, which meant fewer panicles of grain to harvest. Perhaps, he thought, that each panicle would be very long, which would make up for the reduced number. He thought about buying a little bag of fertilizer and applying it to see if things would change.

Jose wanted to sell two chickens in order to get one third of a bag of fertilizer, but Elena was against it. First of all, they could not yet be sure of a good harvest because as yet no grains were visible. Second, since the family had no cash on hand, the chickens were a ready source of cash to buy medicine in case one of the children fell ill, of food in case guests came, or for trading in case rice supplies ran low.

She suggested that they wait until the grains were visible and filled, so they would be assured of at least harvesting something. Who knew whether a drought would come so they could harvest nothing.

It was at times like these that Jose realized what a wonderful decision he had made when he married Elena. She seemed to have such good sense, such an ability to analyze, even though she had only barely finished primary school before she had to quit to work in the fields to help support her family. Jose felt disappointed about the fertilizer, but even more, frustrated because he could not provide a better life for Elena and the children. Nothing else to do that hot afternoon but collect some tuba[1/] from the coconut trees, sell what he could, and sit out by the road in front of the local sari-sari store[2/], watching the jeepneys and tricycles pass by while drinking away his worries.

When the panicles did appear and the grains were filling, Jose took the two chickens into town to sell in order to buy a small bag of fertilizer. When he came back, Elena seemed to be upset about something, but Jose wasted no time in applying all the fertilizer to the crop.

Harvest time for the new rice came earlier than Jose had expected. The fertilizer had failed to help either the growth of the plants or increase the size of the panicles. Jose vowed never again to apply fertilizer so late. Elena wanted to say "I told you so," but decided to be supportive of her husband, believing that one has to make mistakes in order to learn from them.

1/ Coconut wine.

2/ Local small store, usually family owned and operated.

Because the rice matured before the wet season was over, the Umeros had to build a special shed in which to stock the rice in order to keep it from rotting in the field. Since the rice was wet when it was put into the shed, some of the grains germinated, while others rotted or turned brown. The wet rice was extremely difficult to thresh, so the Umeros had to spend a longer-than-normal amount of time in threshing. Winnowing was impossible until the rice and other particles dried out. Since daily rainfall was still common, the rice, placed on large straw mats out in the sun, had to be carefully watched and hauled in and out of the shed as weather conditions dictated.

When the rice was finally dried and winnowed, the yield was about three _cavans_[3/] of _palay_, somewhat less than the Umeros normally harvested from that field using their traditional variety. Their expectations had not been fulfilled, even with all the extra expense and effort they had put in.

Jose felt that he had failed, and went to see the extension agent who gave him the seed. He complained that the seed was mixed with other varieties, and that the shorter variety hardly produced at all. The extension agent asked Jose if he had followed all of the recommendations he had given him. Jose stated that he had not, and began to explain the reasons why. While he spoke, the extension agent kept looking down and fumbling with some papers on his desk, making a comment or asking a question from time to time without looking up. When Jose finished speaking the agent looked up, shrugged his shoulders, and continued fumbling with papers on his desk.

3/ Cavan = 44 - 50 Kg.

On top of everything else, the milling and eating quality of the new rice was poor. When one of the "rolling rice mills" passed near their house, Elena rushed out with a bag of palay to be milled so that the family could try the new product. What she got back was disappointing, as the percentage of broken grains was quite high. She prepared the rice, but her family did not want to eat it. They did not like the taste, the texture was bad, and it wasn't sticky enough. Jose suggested selling it to the NGA (National Grains Authority) at the fixed government price, or to the Chinese middlemen who come around offering low prices for palay whenever the NGA warehouses were full and farmers are desperate to sell. Elena said she would be ashamed to sell it, and that she would feed it to the pig and use it to raise a few more chickens.

Umero's cropping system since 1975

In 1975, Jose heard about experiments that were being conducted in the area on growing two crops of rice in one year. That sounded like a great idea if only it were possible. He knew of a local variety, Kapopoy, which farmers in the area usually interplanted with corn on their higher fields with lighter soils. They did this in years when a typhoon would bring rain before the normal onset of the wet season. The only thing that farmers could be sure about the rainfall is that it never took the same pattern from year to year. The rains could begin early (April) and end early (September), they could begin late (July), and end early (September), or some intermediate pattern could occur. Furthermore, the period before the onset of the rains was often unstable; a typhoon, then drought, another typhoon, then drought again, and so on until rains were no longer intermittent.

Jose dry seeded Kapopoy on his best field (most able to retain water) just after the first typhoon in April. Fortunately, heavy rains came in April that year and the Umeros were able to harvest a good crop of rice during early to mid-August. Shortly thereafter, Jose prepared a seedbed for the photoperiod sensitive variety, BE-3, which would mature in December. He then proceeded to prepare the land for transplanting, plowing twice and harrowing four times in order to puddle the soil and control weeds. By the end of September, all of the field was planted. The yield obtained at harvest in December was not as good as that of the previous crop, nor as good as yields they had obtained from BE-3 in previous years. Nevertheless, Jose and Elena decided that there was promise in double cropping and were glad to have the extra stock of rice. As it turned out, 1975 had been a very good year in terms of rainfall and the length of the growing season.

During 1975, the Umeros were contacted by people from the Cropping Systems Program of IRRI, and were asked to provide information about their daily farm activities, income and expenses, crop choices and yields, and a monthly inventory of their livestock. From the IRRI people, they heard about new rice varieties similar to the ones they had tried in earlier years. The Umeros were understandably skeptical, but liked the "early maturation" quality of the new varieties. Improvements, they were told, had also been made in eating quality and pest and disease resistance.

Before the start of the 1976 crop season, Jose was able to obtain some seed of two new rice varieties being used by a neighboring farmer, IR-28 and IR-36. Even though some farmers in the area had achieved good results with the new rice, Jose remembered his earlier experience with new rice varieties and was not willing to plant them on his best land.

Largely due to their good luck the previous year, the Umeros decided to again direct seed (dry) Kapopoy on their lower field after the first April rain. He did the same with the IR-36 on a small parcel near the middle of this higher field. Rainfall during April after Jose had planted was scarce. The seeds germinated, and there was a farily long spell without rain (two weeks). Many of the seedlings died, especially in the paddy where IR-36 was planted. Jose also noticed an unusually large number of weeds. There wasn't much he could do then, because he was busy preparing a seedbed and plowing and harrowing other fields which would soon be transplanted with the variety Kabangi. The dry seeded Kapopoy crop was also highly weed-infested, but a greater percentage of seedlings survived the drought because the lower field had retained more moisture.

The original stand in the IR-36 field was poor, so Jose broadcast the rest of the seed his neighbor had given him into the more sparsely populated areas. Weeds were thick and the crop continued to look bad, and Jose wondered if there would be any harvest at all. When he had time, he visited the fields of other farmers to compare their crops. Many of the farmers in the area had planted later than Jose, waiting until the fields were flooded before preparing land and broadcasting pre-germinated seed (wet seeding). The stands in the wet seeded fields were much better than his, and weed problems were significantly less because farmers had had time to more thoroughly prepare their fields.

The only thing Jose wondered about was whether or not it would still be possible to get in a second crop if one waited much after April to plant the first crop.

The Umeros experience in 1976 with double rice cropping did not turn out to be nearly as good as the year before. The dry seeded Kapopoy yield was down from the previous year. IR-36 and IR-28 matured at different times, so they were difficult to harvest - the field barely yielded enough for seed for the next year. Jose transplanted BE-3 as a second crop following Kapopoy, but the yield was low due to early termination of the rains. The Umeros worked hard during the dry season, greatly increasing the area planted to watermelon, in order to avoid falling too deeply in debt.

Many of the farmers who were able to plant only one crop of IR-36 produced more than Jose did with his double crop. Farmers seemed to prefer IR-36 over the other new varieties, both for its high yielding ability and for its eating quality. Many people found the flavor and consistency of IR-36 similar to that of the more popular local varieties.

Mainly due to the information gained the previous year, the Umeros decided to switch from dry seeding to wet seeding for the 1977 crop year. Jose's confidence in the new varieties was strengthened by what he had seen and heard, so he decided to plant nearly all of the farm to IR-36 and IR-28 with the seed that he had saved. Always in the back of his mind was obtaining a second rice crop, so he hoped for an early onset of the rains so he could get the first crop established as soon as possible.

Jose knew that his best chance for a second crop was on lower fields (plain), so he started land preparation in late May when heavy rains enabled puddling. He finished land preparation and seeded IR-36 at the end of June, and then began working on the sideslope. He finished wet seeding IR-28 on the sideslope by the middle of July.

The Umeros began to harvest IR-36 on the plain in the third week of September. For this process, Jose employed mostly hired laborers, who received 1/6 of the palay harvested for cutting, bailing, hauling, threshing and winnowing. Elena supervised the measuring and took care of the drying. The IR-28 was ready for harvest a week later, so more hired laborers came in to harvest the sideslope fields.

Because the Umeros were hiring labor for harvest, Jose was free to begin land preparation for the succeeding crop. As the harvesters cleared a field, Jose began plowing it. His intention was to at least get the lower fields plowed and planted for a second rice crop. September rains were quite heavy, and land preparation on the plain was quite difficult due to heavy flooding. At the same time, Jose began to expect that heavy rains would continue or that the end of the season would be later than usual, as the beginning had been late. This meant that he might be able to get a good second crop on the sideslope if he could get it planted soon and rains continued. In the middle of October he decided to shift his land preparation activities to his higher sideslope fields. Jose worked extremely hard getting the land ready as soon as possible, because when the rains stopped, the higher fields would dry out quickly. He finished preparing and wet seeding all of his fields during the last week of October.

Unfortunately for the Umeros, the rains did not continue to be heavy, the rainfall levels dropping to less than 100 mm per month in November and December. Per hectare yields and net returns for the second rice crop were very low.

CHAPTER 5

ANALYSIS OF CURRENT AND PROPOSED CROPPING SYSTEM TECHNOLOGY

The purpose of this chapter is to examine specific proposed and current farm technologies for their appropriateness in light of information regarding farmer's decision making patterns (Chapters 3 and 4) and the prevalent physical, biological and socioeconomic conditions (Chapter 2 and the appendices).

It is widely accepted that even the poorest traditional farmers utilize the resources at their disposal in economically rational ways (Schultz, 1964; Wharton, 1969). Therefore, in order for significant changes to take place, something new must be brought in from the outside, such as a policy action or new technology, in order to facilitate improvements in system performance.[1/]

Technology Evaluation Criteria

Before embarking on the evaluation of new technologies, the underlying evaluation criteria should be expressed. In general, a technology can be considered appropriate for introduction to a farming system if it enhances the productivity of that system and improves the reliability of family food supplies. During the farm interview process, a number

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1/ The fact that farmers are economically rational does not imply that they all manage the resources at their disposal with the same degree of efficiency. Another alternative is to pursue improvement by identifying and recommending what superior farm managers do, which does not necessarily require new inputs.

of criteria were expressed which must be met in order that a new technology be acceptable to farmers. As a result of interaction with farmers and a review of work by other researches (e.g. Collinson, 1978), the following criteria were selected for assessing current and potential farm technologies.

1. <u>Resource utilization.</u>

   How does the technology in question make use of scarce resources (e.g. land and capital) and plentiful resources (e.g. labor)? Technologies which maximize the use of abundant resources or minimize the use of scarce resources will be favored.

2. <u>Contribution to household objectives</u>

   Will the new technology increase the quantity of preferred food for family subsistence or the amount of income derivable from productive activities? Is food produced at times when family food stocks are usually running low? Does the new technology enable production at previous levels at a reduced resource cost? In order to be acceptable to farmers, any new technology should be production (income) increasing, cost reducing or both.

3. <u>Institutional requirements</u>

   What will be the effect of the new technology on the community resource system? Will new inputs, or greater quantities of current inputs, have to be provided? Are marketing channels available for the increased output? Input delivery systems (including credit) are often poorly developed in rural areas.

This fact tends to favor technologies that do not call for great changes in resource delivery systems over those that do.

4. Managerial requirements

Small farmers generally make changes in small steps which they view as consistent with their circumstances, abilities and risk preferences. They rarely adopt complete complex technological packages, which are sometimes quite dependent upon appropriate timing of crop activities (e.g. planting, fertilizing) and high levels of non-traditional capital inputs (e.g. fertilizer). Preferred technologies are those which are flexible; only a few, fairly simple managerial adjustments are required and the success of the technology is not overly contingent upon timing and level of input use.

5. Agroclimatic requirements

Is the new technology compatible with the natural circumstances prevalent in the area? New technologies must fit into the natural environment, especially when new crops or crop sequences are being proposed.

6. Acceptability to farmers

The criterion of farmer acceptance summarizes the preceding criteria and allows for the inclusion of other criteria that may not have been detected previously. Farmer acceptance of existing technology can be objectively determined by examining adoption trends. Judging the acceptability of notional technologies is more difficult, as farmers cannot draw upon their own experience with the technology in order to reach a conclusion. Once the characteristics of the technology have been explained, however, most farmers are able to predict a likely response.

Traditional Rice Technology

Before discussing and evaluating new rice technology, a description of traditional technology is necessary in order to facilitate comparison. Traditional technologies evolving over time tend to adapt to environmental requirements, bringing certain rigidities to agricultural production systems. An example of the phenomenon is the use by farmers of traditional rice varieties which mature only during certain times during a year when specific daylength requirements are met. In Iloilo, the most common traditional rice varieties mature in December when nearly all rains have subsided. It is quite beneficial to be able to harvest rice at the beginning of the dry season, when plenty of sunshine is available for solar drying. This minimizes losses due to grain rotting and germination and facilitates the maintenance of acceptable standards of grain quality. Moreover, traditional varieties mature at the same time, regardless of planting date, enabling farmers forced to plant late in years of late rainfall onset to catch up while sustaining relatively minor yield losses. As shown in Figure 5.1, a traditional rice variety can be planted in June and harvested in December. Two months would remain for possibly growing an upland crop after rice.

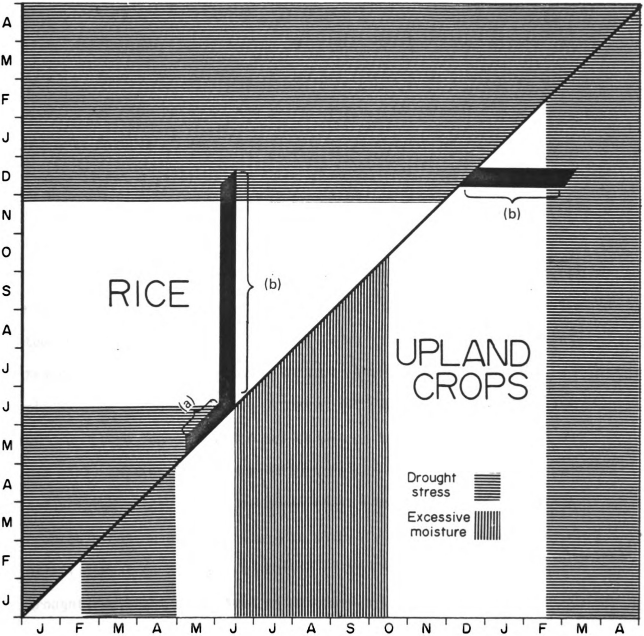

Figure 5.1. The suitability of traditional cropping practices to Iloilo agroclimatic conditions.

Note: Time for land preparation activities is measured along the diagonal (a), while time for planting through harvesting is represented as bars emerging from the diagonal (b).

One disadvantage of the traditional varieties is the simultaneity with which labor is demanded for specific crop activities, especially transplanting and harvesting. It is possible to stagger land preparation, seeding and transplanting of traditional varieties without much penalty, though the tendency in rainfed areas is to plant nearly simultaneously with the onset of the rainy season. At harvest time, all rice in the area matures at once, creating a large demand for harvest labor. As Iloilo is not a particularly labor abundant area, the harvesting process for any one farm often lasts the whole month of December and absorbs large amounts of labor, thus creating a labor "bottleneck."

An actual labor profile for a rainfed farm planting only traditional rice varieties is presented in Figure 5.2. Land and seedbed preparation took place during the June to early August period. Seedlings were transplanted during mid-August through early September, and the mature plants were harvested during December and January. Due to the lateness of crop establishment, which was caused by a late rainfall onset and the early termination of the rainy season in 1977, no upland crops were established either before or after rice. The early onset of rainfall enables planting of an upland crop such as green corn before rice crop establishment on at least a portion of the farm. Alternatively, drought-resistant crops such as mungbean and cowpea can be successfully planted after rice on lower fields with heavy soils capable of retaining sufficient amounts of moisture.

Evaluation of Existing New Technologies

With the technology evaluation criteria in mind, three alternative existing technologies are evaluated to determine their suitability to

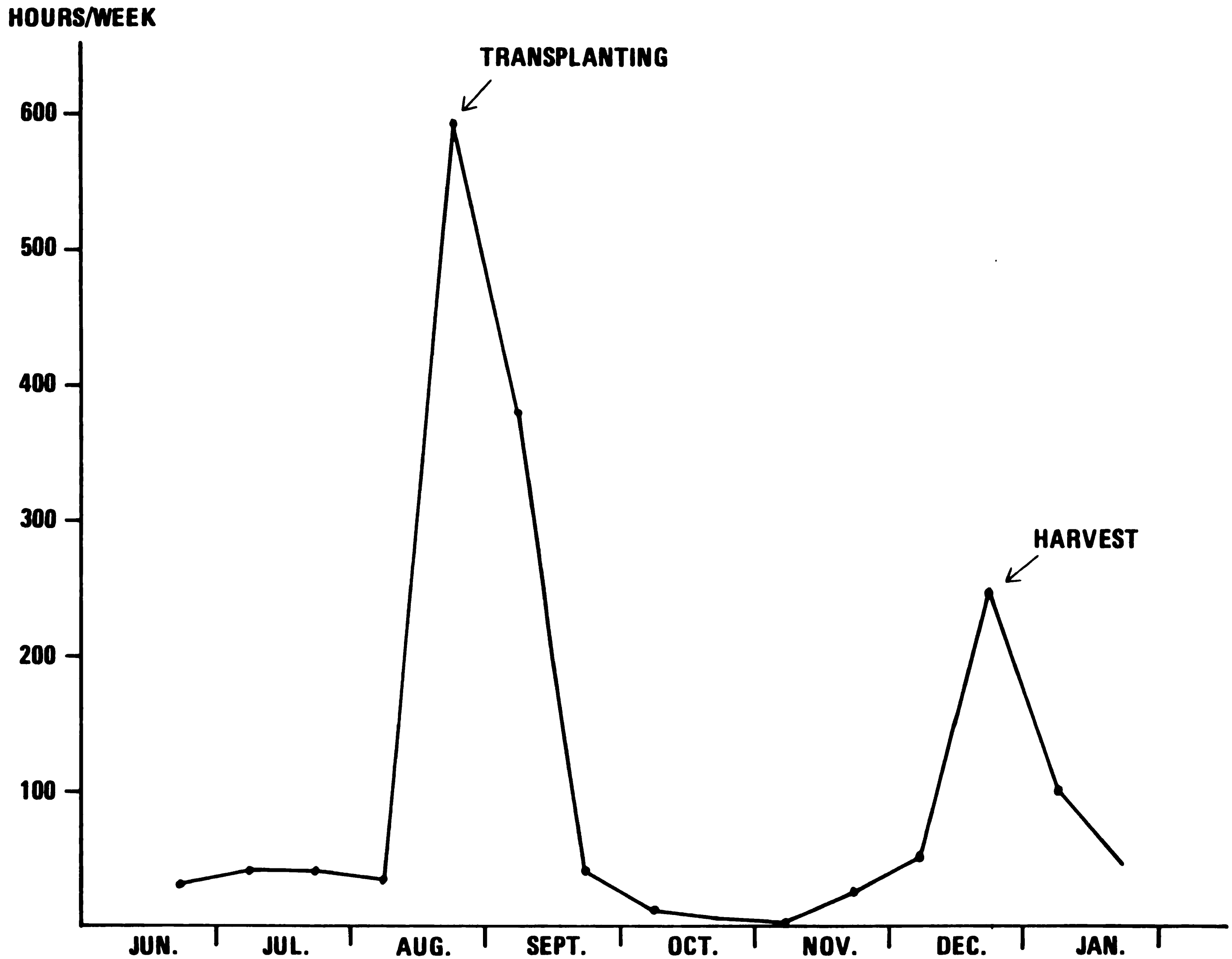

Figure 5.2. A labor profile for a rainfed rice farm planting traditional rice varieties.

current farming systems in Iloilo. One of the technologies, namely the utilization of early maturing varieties, is already in an advanced stage of adoption by Iloilo farmers. The remaining existing technologies have been tested by the CSP on farmers' fields, but their adoption is not yet widespread. All of the technologies discussed pertain to the growing of rainfed lowland rice.

Existing Technology 1 - Early maturing varieties (EMVs)

Resource utilization. The early maturation characteristic of new varieties causes them to use land for a shorter period during the wet season than do traditional varieties. This allows greater cropping intensity if the time gained during the wet season can be used productively. Low photoperiod sensitivity allows better use of a usually abundant resource, labor. The EMVs require generally as much labor as do the traditional varieties, but some of the requirements during periods of high labor demand can be reduced. For example, labor requirements can be spread out over time by staggering land preparation and planting. Furthermore, since new varieties are of a relatively fixed field duration, harvesting labor requirements can also be spread out.

In order to realize their yield potential, EMVs require increased amounts of fertilizer (especially nitrogen). This implies the increased use of relatively scarce small farm resources, namely cash or credit to obtain the needed inputs. Recommendations by researchers also call for increased use of other complementary inputs such as herbicide and insecticide. These inputs, however, appear to affect yield less strongly than does fertilizer.

Contribution to household objectives. Early maturing varieties provide the potential for increased food production and farm income through increased yield per planted crop and through the possibility of increasing the number of crops planted on the same field during a crop season. Since the time between planting and harvest is reduced, food becomes available earlier in the season to replenish diminishing stocks, an important advantage to those farmers producing at or near subsistence levels. Although many of the new varieties approximate the eating quality of traditional varieties, some farmers continue to plant preferred traditional varieties to fill family food needs while planting new varieties for income generation.

Institutional requirements. The EMVs require an increase in the application of productive inputs, especially fertilizer. However, farmers generally apply amounts of inputs less than those recommended by researchers. Increasing yields and cropping intensity have greatly increased the amount of grain which passes through the largely government-controlled marketing system. Storage capacity is a major problem in the Iloilo area. The government offers to buy rice at a fixed price until its storage capacity is filled. At that point, the informal market begins to function. During periods when large amounts of rice are being harvested and the government is no longer able to purchase rice, produce is sold through local intermediaries, often at prices substantially lower than the government "guaranteed" price. Thus, while production may have increased, the possibility exists of a net reduction in farm income if the reduced output price received by farmers more than offsets the value of the increased production.

Managerial requirements. Modern varieties were developed on experiment stations under tightly controlled environmental conditions. Based on those experiments, recommendations were made as to crop management practices necessary to achieve maximum output. The recommendations were rather rigid, calling for large amounts of capital inputs and a high degree of water control. Furthermore, the recommendations contained strict guidelines as to the timing of operations such as transplanting and input application. In general, small farmers do not possess the quantity and quality of resources necessary to carry out these management recommendations.

The early maturation characteristic has reduced the risk of yield loss due to drought stress, as EMVs are normally harvested within the bounds of the rice growing season. Traditional varieties, on the other hand, generally mature in December, and often face drought conditions before harvest.

Agroclimatic requirements. Early maturing rice varieties planted in June are ready for harvest in approximately 110 days from the date of initial planting, allowing for the possibility of planting a subsequent rice crop or an upland crop.[2/] A second rice crop, however, would face a high probability of drought stress in the flowering and maturity periods (Fig. 5.3). Information gathered from CSP cropping pattern trials in Iloilo demonstrates that expected yield from second rice crops are roughly one-half the yield levels of rice crops established at the

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2/ When transplanted, EMVs take slightly longer to mature (one to two weeks) due to time lost as each plant "recovers" from transplanting.

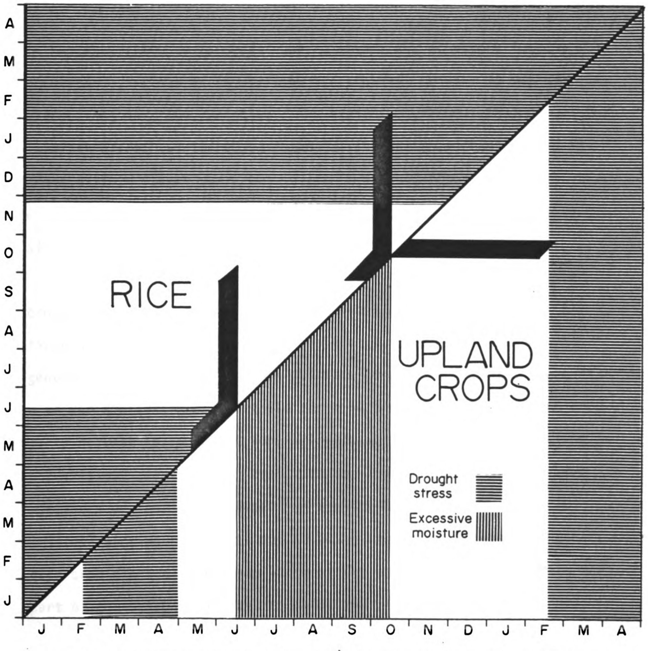

Figure 5.3. Agroclimatic suitability of early maturing rice varieties to Iloilo conditions.

beginning of the wet season for all landscape positions.[3/] Moreover, while first crop yields tend to be somewhat stable, second rice crop yields exhibit large year to year variations.

Acceptability to farmers. During interviews of sample farmers, the question was raised as to why they had adopted, or were in the process ofadopting, new rice varieties. The reasons expressed, in order of their importance are: a) increased potential for multiple cropping; b) increased yield levels per crop; c) early harvest replenishes rice stocks at an opportune time; d) lower incidence of pests and diseases; e) resistance to lodging.

Ten out of twelve farmers interviewed listed increased multiple cropping potential as the principal advantage of new varieties. All farmers mentioned increased per crop yields as important, though generally less significant than multiple cropping potential. Farmers with the smallest areas suitable for rice crop establishment mentioned early harvest as important for replenishing their family's dwindling or non-existant rice stocks. Pest, disease and lodging resistance were mentioned by less than one-half of the sample.

The reaction to EMVs is not entirely favorable, however. The harvest of a crop planted at the beginning of the wet season occurs during the part of the season when the frequency and intensity of rainfall are high. The rice must be harvested wet, causing the manual threshing process to be more difficult and time consuming. Significant grain

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3/ Refer to Appendix A, Tables A.3 and A.4 for more detailed information.

losses may also be incurred due to grain rotting and germination if rice is allowed to remain wet over a long period. The most common method of drying rice is the use of solar energy, a scarce resource in the wet season.

On balance, the advantages of the new varieties seem to outweigh the disadvantages, as evidenced by both the adoption behavior of farmers (Figure 3.9) and their verbal responses.

Existing Technology 2 - Dry seeded rice crop establishment (DSR)

As stated in Chapter 3, dry seeded rice is not a new technology. The use of of DSR in conjunction with new varieties, however, is new.

Resource utilization. The principal advantage of DSR is that it allows the early establishment of a rice crop at the beginning of the wet season. This can enable a second rice crop to be grown under relatively favorable moisture supply conditions (Figure 5.4). If the second rice crop can be planted and harvested soon enough, the possibility also exists for a third planting under conditions favorable for the growth of upland crops. Adoption of the DSR technique would increase the requirement for land preparation labor during a period when little or no farm work usually takes place. Capital requirements are similar to those required for planting early maturing varieties using other seeding methods witn the possible exception of herbicide. Since dry land preparation does not effectively control weeds, the use of herbicide appears to be a necessary pre-condition for the adoption of DSR.

Contribution to household objectives. To the extent that DSR facilitates increased cropping intensity, the ability to meet household food

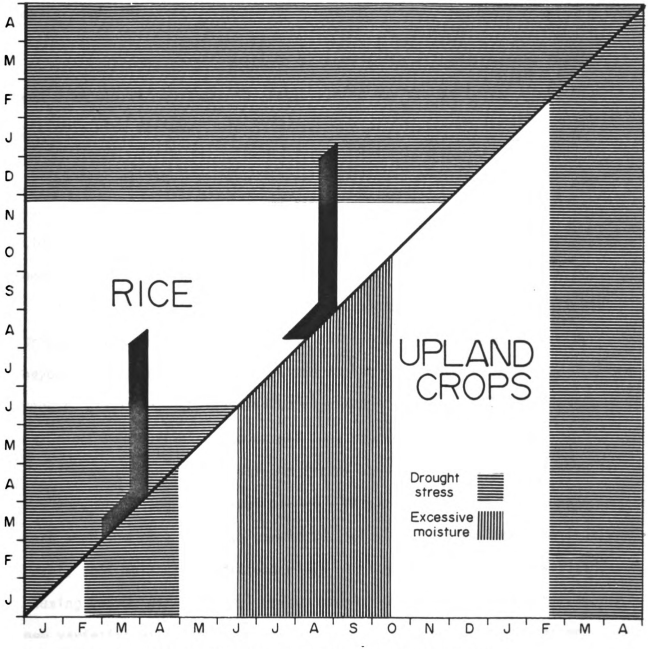

Figure 5.4. Suitability of DSR under typical Iloilo agroclimatic conditions.

requirements and increase farm incomes will be enhanced. Because planting takes place early in the season, rice stocks can be replenished at an early date.

Institutional requirements. The institutional requirements for DSR would be similar to those for establishing any new early maturing, high yielding rice variety.

Managerial requirements. Three significant problems have been encountered with DSR as a planting strategy: a) poor and uneven germination; b) death of germinated seedlings due to drought; and c) excessive weed growth.

Problems a) and b) are influenced by the nature of the rainfall distribution before the onset of heavy sustained rains. Thus, they are beyond the farmer's control once the fields have been prepared and seeded. Problem c), excessive weed growth, is controllable by farmers assuming that sufficient labor and cash resources are available.

Timing in DSR is critical, as fields must be prepared and planted at the very beginning of the wet season. After seeding, rainfall causes both weed and rice seeds to germinate. Since fields are never perfectly level, soil moisture conditions differ in different parts of the field, causing uneven germination. Due to their low photoperiod sensitivity, new varieties will mature in roughly a constant period of time after germination. Therefore, if germination occurs unevenly, maturation will also be uneven, thus delaying or complicating the harvesting process.

Agroclimatic requirements. Poor initial crop stands are likely if there is either too much or too little rainfall. If rainfall is heavy soon after dry seeding and sufficient water accumulates, seeds and young seedlings may drown. On the other hand, a two to three week dry spell after seeds have germinated can cause the death of a high proportion of young seedlings.

As rainfall tends to be unstable in both frequency and intensity at the beginning of the wet season, the probability of poor initial crop stands combined with strong competition from weeds is high. The type ofdamage likely to be suffered depends upon the position of the field within the topographic sequence and the type of soil. For example, paddy fields on side slopes or fields with light soils would be most likely to receive insufficient moisture to support a dry seeded crop in its early stages. Dry seeded fields in the lower landscape positions, or with heavy soils which easily impound water, would be most susceptible to flooding damage should initial rainfall be intense or very frequent.

Acceptability to farmers. Interviews and discussions were held with farmers trying DSR during the period of crop growth and subsequent to its harvest. Farmers who decided not to try DSR cited rainfall uncertainty and high expected weed growth as the main reason for their choice. Of the three farmers that did try DSR, two said that they did not plan to repeat the technique the following year, due to poor yields caused by the previously mentioned conditions. The third farmer, who established DSR on a very low landscape position, achieved good results and is planning to continue the practice in the future on the same fields.

Examining the performance criteria stated at the beginning of this chapter, one finds DSR deficient on two points. First, it appears that the levels of handweeding labor and cash for purchase of chemical inputs that farmers must have available in order to successfully utilize the technology are higher than farmers are willing or able to allocate. Second, DSR increases rather than reduces the effects of uncertainty on the farm system. In order to achieve the potential benefits desirable from DSR, the farmer must subject himself to a higher probability of yield loss due to flooding, drought stress and competition from weeds. Finally, with respect to farmer acceptability, the adoption of DSR as a crop establishment technique has been quite low.

Existing Technology 3 - Transplanting the second rice crop (TPR)

One means of increasing the potential yield of a second rice crop following the harvest of an EMV is to transplant the succeeding crop using mature (35-45 days-old) seedlings (IRRI, 1979). The second rice crop, also an EMV, must be sown in seedbeds before the harvest of the first crop and transplanted into the main field once the previous crop is harvested and the field has been prepared. The transplanted crop will mature in about 75 days after the date of transplanting (Figure 5.5). The probability of yield reduction due to drought stress is reduced as the amount of time necessary for the crop to be in the field after transplanting is shortened.

Resource utilization. Transplanting the second rice crop with 35-40 day-old seedlings can enable farmers to harvest two rice crops in a single season with a low risk of severely reduced yields for either crop. There are, however, two significant factors which limit the adoption of this technology:

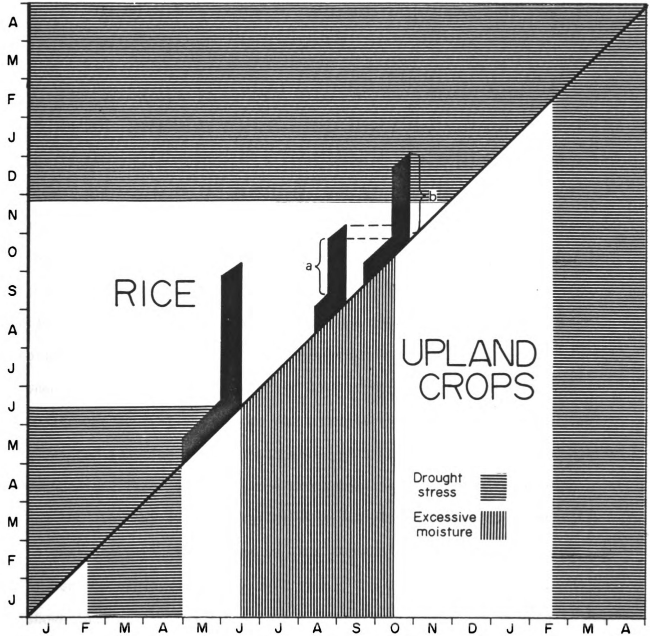

Figure 5.5. **Transplanting a second rice crop with older seedlings under Iloilo agroclimatic conditions.**

Note: a. Seedling growth
b. Main crop growth

1. A portion of land must be set aside (not planted to a first rice crop) for seedbed preparation.
2. Labor must be available for transplanting when seedlings are mature and fields are prepared.

The first factor is relevant mainly to the smallest farms. Part of the income generated by a transplanted second crop must pay the cost of the foregone oppportunity of a first crop of rice growing on the seedbed area. The second factor mentioned, that of transplanting labor availability, is probably most significant. During the time when transplanting of the second crop should take place, rice crops on other fields in the surrounding areas are being harvested. The wage rate for harvest labor (including threshing) is based on a crop share, while the transplanting wage is usually a fixed amount. The transplanting wage was set when mainly traditional varieties were being used, and few alternative employment activities existed for transplanting labor. With the greatly increased adoption of non-photoperiod sensitive varieties, opportunities for harvest labor are available throughout most of the rice-growing season. The harvest wage varies with the yield of the crop, generally in the same direction. That is, the higher the yield per unit area, the higher the harvest wage per unit time. The analysis of farm records has shown that harvest wage rates vary from roughly equal to as much as four times the transplanting wage.[4/] Since many of the harvesters are

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4/ These figures reflect valuation of the harvesters' crop share at the farm gate price of rice.

landless laborers, their share of the harvest may be worth something closer to the retail price of rice than the wholesale or farm gate price. If the rice earned is used for consumption, then a milling fee is the only additional cost, as they often transport the rice themselves and have no marketing expenses to pay. Therefore, the real harvester wage was as high as eight times the wage being offered for transplanting. This of course restricts the supply of labor for transplanting during harvest time.

Contribution to household objectives. Transplanting the second rice crop allows farmers to increase their cropping intensity, thereby increasing food production and farm income.

Institutional requirements. Transplanting is a common farm practice which requires no new capital inputs from outside the system. Other requirements would be similar to those which would necessarily accompany the adoption of any new variety.

Managerial requirements. Managerial changes associated with the adoption of this technology would be minimal, as farmers are already familiar with transplanting techniques. The changes that would have to occur involve reducing the amount of land planted to the first rice crop in order to provide space for growing a seedbed, increasing the seedling transplanting age in order to reduce the amount of time the crop is in the field, and increasing the density of transplanted seedlings.

Agroclimatic requirements. As demonstrated in Figure 5.5, transplanting the second rice crop enables the two-crop sequence to fit mostly within the time period alotted for rice production. The major difference from previous recommendations for transplanted rice concerns the age of the seedlings upon transplanting. Experimental trials undertaken at IRRI in 1978 evaluated yield and growth duration effects of old seedlings. Average grain yields were significantly reduced when old seedlings were used when the transplanting intensity was three seedlings per hill. However, the use of an increased number of seedlings per hill was found to increase the yield of plots planted with 40-day-old seedlings to levels similar to those planted with 18-day-old seedlings (IRRI, 1978; Table 31).

Acceptability to farmers. Farmers in Iloilo have demonstrated a general reluctance to allocate land to seedbeds and to forego the more certain first rice crop for what they consider to be a less certain outcome for a second rice crop. Furthermore, farmers have been well versed on the necessity of transplanting EMV seedlings early (18-20 days after seeding). They therefore expect inferior yields using the older seedlings that form the basis of this new technology.

In Iloilo, there is not an overabundance of landless people offering their services as temporary agricultural laborers. In fact, many farmers with small holdings forego productive opportunities on their own farms in order to work as harvesters in neighboring larger farms. Moreover, it is unlikely that farmers in the area would be willing to increase transplanting wages sufficiently to attract labor that would ordinarily be used in harvesting.

In evaluating this technology according to the criteria for appropriateness presented at the beginning of this chapter, we find that transplanting the second rice crop can improve the productivity of land (by increasing expected yield) and can reduce the effects of uncertainty on the farming system (by reducing the risk of yield loss due to drought stress). However, it is not compatible with the level of labor and capital farmers are willing and able to reallocate.

Evaluation of Notional Technologies

The previously evaluated technologies can be considered relatively developed in the sense that at least preliminary field testing and evaluation has occurred. As demonstrated in previous chapters, a large scale adoption of Existing Technology 1 (EMVs) by farmers has already taken place. Existing Technologies 2 and 3 have been developed and tested, but adoption by farmers is not yet widespread. In this section, fournotional new technologies will be briefly described and evaluated in the context of Iloilo rainfed farming systems.

Notional Technology 1 - Very early maturing varieties (VEVs)

As mentioned previously, early maturing varieties do not provide the opportunity for double rice cropping under rainfed conditions without entailing a substantial risk of yield reduction due to drought stress of the second rice crop (Figure 5.3). One potential means of allowing double rice cropping under less risky conditions would be to develop varieties with an even shorter maturation period (Figure 5.6).

Resource utilization. By enabling the planting and harvesting of two rice crops per season, VEVs would require increased amounts of labor and capital inputs than are currently employed under single crop production systems. Land would become roughly twice as productive as it currently is in areas where multiple rice crop potential is low using existing EMVs.

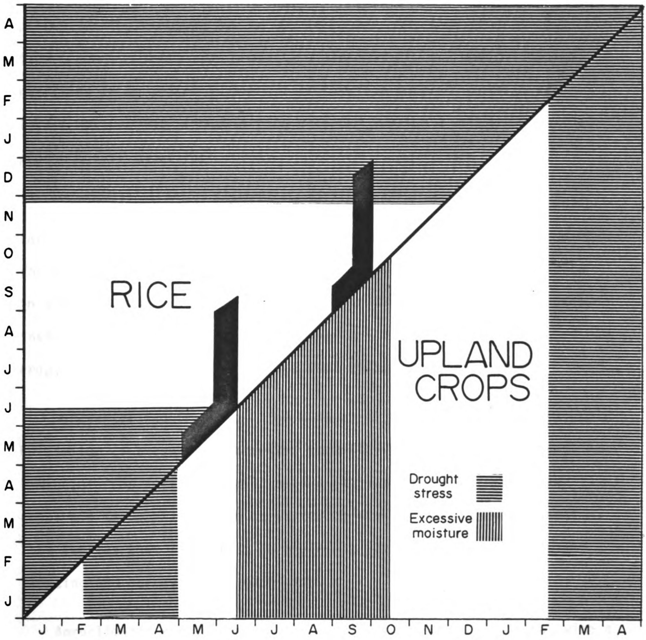

Figure 5.6. Agroclimatic fit of very early maturing rice varieties under Iloilo conditions.

<u>Contribution to household objectives</u>. VEVs would contribute an increased supply of rice earlier in the season than late maturing varieties. Initial adopters of such varieties would likely obtain higher prices for their output due to the early harvest, thus generating greater farm incomes. Total rice production per unit of land would increase, resulting in an increased overall family food supply. Nutritional levels may decline if double rice cropping implies a reduction in the production of other food crops.

<u>Institutional requirements</u>. No new inputs, other than seed (which farmers can produce themselves after the first year), would be required for VEVs. Levels of common capital inputs would need to be increased in a manner compatible with the growing of two crops of rice in a season instead of one. Marketing problems may arise, especially for the second crop, because governmental storage facilities may already be full.

<u>Managerial requirements</u>. The managerial requirements for VEVs would be similar to thoser for varieties currently used by Iloilo farmers. Timing of crop activities will become increasingly important if two rice crops are to be planted and harvested before the end of the wet season. This implies that labor must be available for timely land preparation, planting and harvesting of each crop.

<u>Agroclimatic requirements</u>. For rainfed areas such as Iloilo, with a 5-6 month rice growing season, rice varieties with field duration of about 90 days can be double cropped using wet seeded establishment techniques (Fig. 5.6). Both crops can be grown at least through the flowering stage during the period of the year that the probabilities of obtaining sufficient rainfall to support normal rice crop growth are high.

Scientists have already succeeded in breeding very early maturing varieties. In addition, rice varieties typically grown in temperate climates produce much more rapidly in the tropics, some in as little as 70 days. However, experimental results at IRRI appear to demonstrate a positive correlation between maturity and grain yield (Figure 5.7). The earliest maturing variety currently being recommended for use in the Philippines is IR28, which matures in 105 days. There is some question as to the physical feasibility of producing new varieties with significantly reduced field duration periods that still provide the high yield potential of some of the later maturing varieties currently in use. Significantly lower yield expectations could reduce the attractiveness of very early maturing varieties vis a vis other currently available production technolgies.

Acceptability to farmers. When questioned as to the potential desirability of varieties with a very short field duration, all farmers responded affirmatively. In fact, some of the farmers were already experimenting with Japanese varieties that were said to mature in as little as 70 days in the Philippines. Most farmers who tried these varieties reported that yields were unacceptably low and that grain quality was inferior. The Japanese varieties would have to be improved upon in these two aspects before becoming acceptable to farmers.

Very early maturing varieties for the rainfed farming system appear promising providing problems of low yield and grain quality can be overcome. The major positive factor would be the reduction of uncertainty in the system with respect to rice yields, as both crops could be fully grown under favorable conditions for rice.

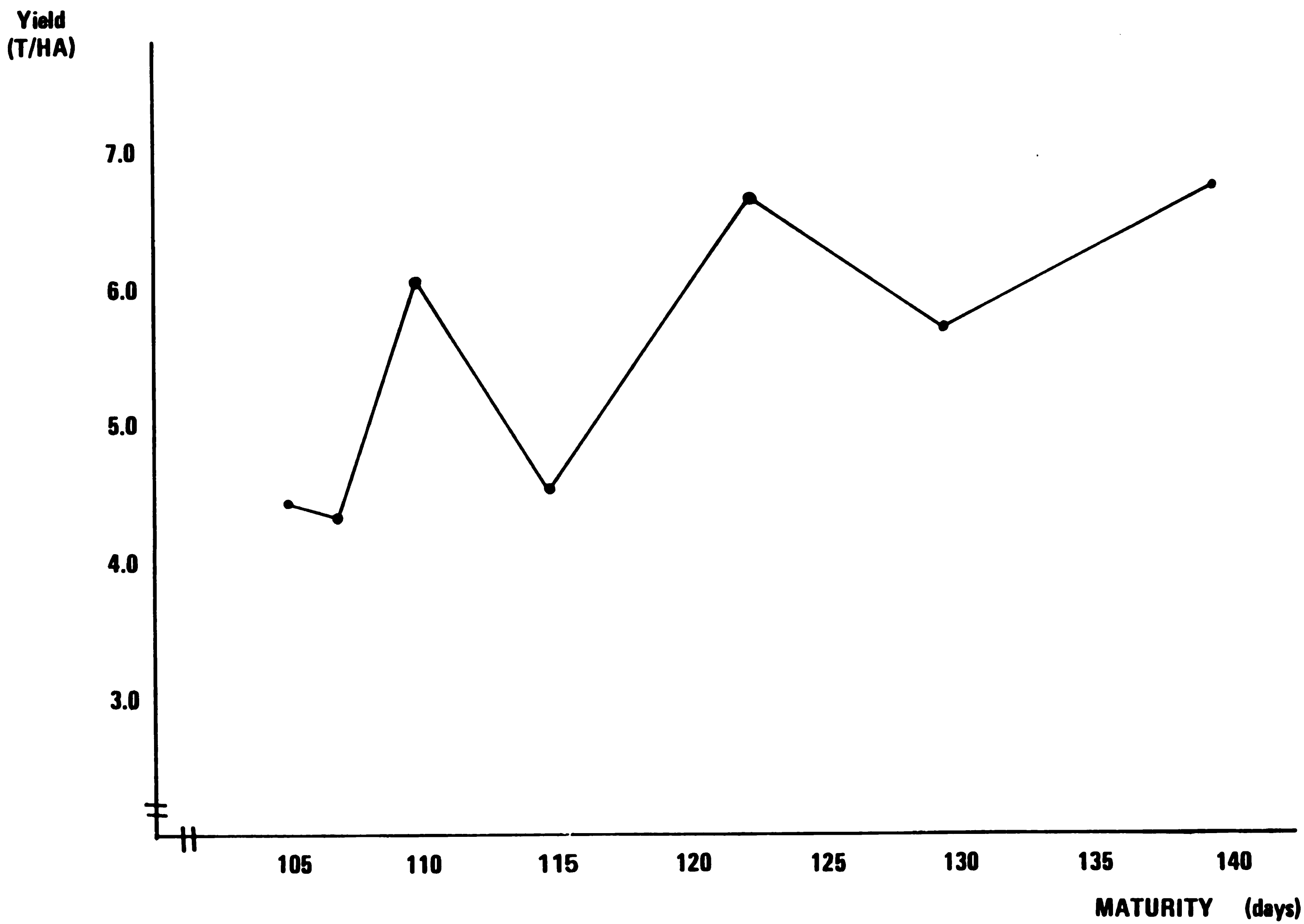

Figure 5.7. Relationship between average grain yield and maturity period of ten IRRI varieties recommended for the Philippines.

Notional Technology 2 - Late maturing varieties (LMVs)

If the positive relationship between rice yields and maturity period is confirmed, it may be possible to increase output over current levels by growing a long duration, non-photoperiod sensitive high yielding variety which can then be followed by an upland crop (Figure 5.8). The principal advantage of a non-photoperiod sensitive LMV over traditional varieties is that it would be harvested earlier in the season, leaving more time for establishing a subsequent upland crop under favorable conditions. On fields in the higher landscape positions, where yield loss probabilities tend to be highest for a wet seeded second rice crop planted late in the season, double rice cropping may not be viable in most years. In such areas, the planting of a late-maturing, high yielding single rice crop would be preferable over a single short-duration rice crop. Ample time would remain for planting a succeeding upland crop.

Resource utilization. The development of LMVs would not require large changes in current cropping practices. Land use intensity would increase somewhat as more upland second crops could be planted. Labor and capital use would remain virtually the same, with changes occurring only in timing.

Contribution to household objectives. Due to improved yield characteristics, a modest increase in rice production would be expected. Similarly, due to an early harvest, the potential for planting upland crops

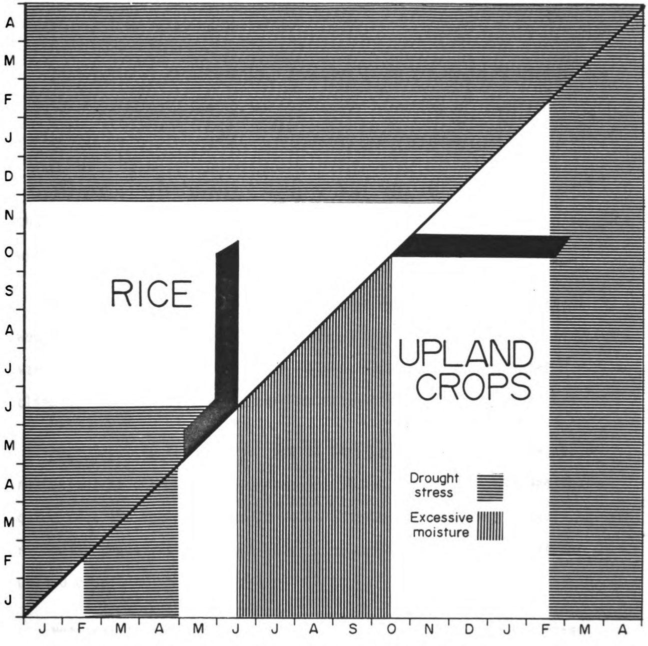

Figure 5.8. Suitability of a late maturing variety under Iloilo agroclimatic conditions.

after rice would also increase (Figure 5.8). Assuming stable price levels, this would provide increased farm income as well as food for home consumption. The timeliness of food provision would not vary substantially from existing patterns.

Institutional requirements. Adoption of an LMV would require no new inputs or policies. Due to the similarity in timing to traditional varieties, no special market requirements are foreseen.

Managerial requirements. Management of LMVs would be similar to that required of traditional varieties. The level of risk for the second upland crop would, however, be reduced.

Agroclimatic requirements. There is no reason to suspect that an LMV would not be biologically feasible, though most non-photoperiod sensitive varieties are early maturing. In regards to suitability to rainfed climatic conditions, there should be no problem.

Acceptability to farmers. Due to the fact that LMV adoption would not stimulate changes from current practices, farmers interviewed indicated that the technology would be acceptable. They were also able to recognize the advantage in regards to an earlier establishment of the upland crop.

Notional Technology 3 - Photo-sensitive, early maturing varieties (PSVs)

The development of early maturing, photoperiod sensitive rice varieties could be used as a major component in a technology based upon dry seeded rice. Previously, an analysis of DSR-based cropping patterns revealed major problems with respect to maturity and weed growth that would be alleviated or partially alleviated with the advent of such a variety.

High photoperiod sensitivity is a desirable characteristic for a dry seeded rice variety, since maturity is principally determined by day length even though the planting date may vary. One of the major problems with DSR is that of uneven maturity due to uneven germination and subsequent replanting of poor initial stands. Areas which require additional planting can be reseeded once rainfall has stabilized, and the new plants will mature at the same time as the older plants.

Resource utilization. As part of a multiple cropping scheme, the chief desirability of DSR is that it permits the establishment of an initial rice crop as soon as the soil has accumulated sufficient moisture to permit land preparation. The early establishment of the first rice crop greatly improves the chances of planting and harvesting a good second rice crop (Figure 5.4). Capital and labor use intensity would be affected in a fashion similar to any technique which would facilitate the double cropping of rice.

Contribution to household objectives. The utilization of a PSV would allow early rice crop establishment using dry seeding techniques, which in turn enhances the possibility for double rice cropping. The potential would then exist for increased rice production and farm income. Furthermore, two rice harvests would allow greater flexibility in the management of rice stocks for family consumption.

Institutional requirements. No new inputs or policies would necessarily accompany the adoption of this technology. Market effects would be to alter the pattern of supply, enabling rainfed farmers to market their rice crops earlier in the season, thus possibly gaining a price advantage.

Managerial requirements. Crop establishment practices would be altered with the use of DSR techniques. Furthermore, in order to derive full benefit from the PSVs, field preparation must be accomplished at the onset of the wet season. Production risks would be reduced as sparsely populated parts of a field could be replanted and the entire field would still mature simultaneously.

Agroclimatic requirements. The biological feasibility of varieties which flower and mature under day length conditions prevalent during the middle of the rainy season would need to be explored by the plant breeders. The climatic fit of such a variety as the first crop in a two rice crop pattern would be similar to that presented in Figure 5.4.

Acceptability to farmers. The idea of PSVs as notional technology was conceived after completion of field work, and hence was not presented to farmers for judgment. However, the probable benefit of this technol- is that it would alleviate the uneven maturation constraint associated with DSR, which would therefore make the seeding method more acceptable to farmers.

Notional Technology 4 - Ratoon rice varieties (RAVs)

Ratooning of rice is the use of the plant's regenerative ability to produce a subsequent crop (or crops) from field stubble after the harvest of the first crop. The expected yields of a ratoon crop are almost always lower than those of the main crop. The principal advantage, then, is the potential saving of both time and labor. The time-saving feature of ratoon cropping is what makes it most attractive as a potential new technology for rainfed areas with agroclimatic conditions similar to those prevalent in Iloilo.

The principal characteristics of a cropping pattern featuring ratoon are shown in Figure 5.9. Since the period from initial ratoon growth to grain maturity is short, the first rice crop can be established late enough so that the risk of early drought stress is low. In most cases, this implies the use of wet seeding as the initial rice crop establishment technique. Ratoon growth begins immediately after (or sometimes before) the harvest of the plant crop. New shoots are produced at the base of the plant or grow from the nodes of previously cut tillers. Since ratoon matures much sooner than the main crop,[5/] the total duration of the main-ratoon crop is approximately 170 days.

Resource utilization. The growing of a ratoon rice variety would make use of land in the latter part of the wet season which, in cases where growing a second rice crop is infeasible, has no alternative use.

5/ In the case of IR-36, the ratoon matures in approximately 50-60 days after harvest of the main crop.

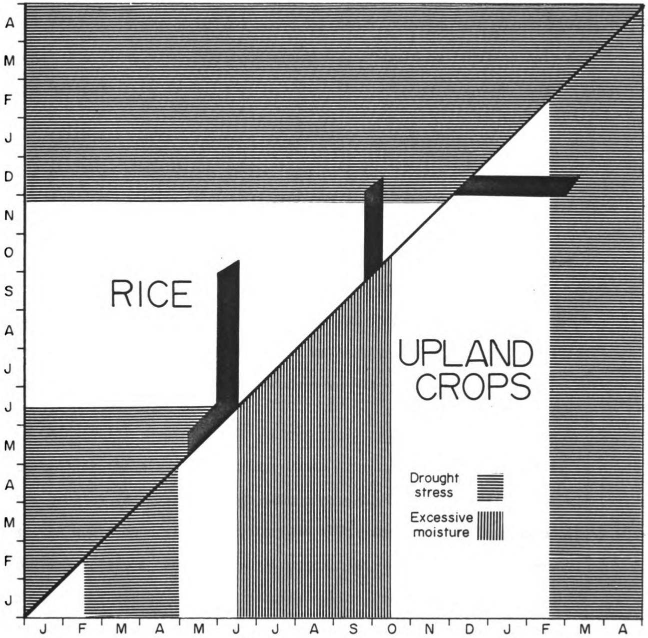

Figure 5.9. Ratoon rice cropping under Iloilo agroclimatic conditions.

A ratoon crop would require few if any additional capital inputs, as the residual nitrogen not utilized by the main crop would be available for the ratoon. Since no effort would be spent preparing and planting land after the first rice crop, additional labor would be required only for the harvest.

Contribution to household objectives. By providing an added rice harvest from areas where double rice cropping is not feasible, ratoon cropping would increase the family food supply and modestly increase farm income.

Institutional requirements. Ratoon technology would not depend upon new or increased levels of inputs from outside. Since expected ratoon crop yields are lower than expected main crop yields, minimal additional stress would be placed on the product market.

Managerial requirements. Ratoon rice cropping requires no new or unfamiliar techniques. The importance of timing of crop activities is not greatly increased, though main crop establishment early in the wet season would be preferable to ensure that both crops would grow under optimal moisture conditions. As the ratoon crop is ready for harvest just at the end of the rice growing season, the probability of substantial yield reduction or crop failure due to drought stress is low. Furthermore, the possibility still exists of planting and growing an upland crop under suitable soil moisture conditions.

Another feature that makes ratoon cropping attractive in a rice-based cropping pattern is the reduced labor requirement (Zandstra and Samson, 1979). Since no land preparation or planting labor is required for ratoon, farmers may utilize otherwise idle land and still avail themselves of alternative employment opportunities such as harvesting on neighboring fields. Ratoon cropping then becomes a complementary rather than a competitive activity, as output can be generated with low levels of inputs and management.

Agroclimatic requirements. All rice plants have a regenerative ability. However, experience with early maturing varieties indicates that ratoon yields can be expected to be much lower than those of the main crop. This is partly because "ratoonability" has not been a criterion for varietal selection in IRRI breeding programs. Results from cropping pattern trials indicate that the average yields of IR-36 ratoon approximate one-sixth of the main crop yield (Component Technology Research Staff, 1979).[6/] While ratoon cropping is biologically feasible and fits the prevalent climatic pattern in Iloilo well, breeding work will have to be done to obtain varieties which make ratooning economically viable.

Acceptability to farmers. The farmers participating in this study were questioned as to their preference between rice varieties currently available and a proposed new variety which would produce about one-third

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6/ No cash inputs (such as fertilizer or pesticides) were added to the ratoon crop, which would in part explain low yield figures.

the yield of the new varieties they were using. All of the farmers had previous experience with ratoon, though few had done it intentionally. Their word for ratoon translated roughly as "volunteer rice". During years in which there was substantial rainfall late in the rice-growing season, some newly harvested rice plants would regenerate. In most years, farmers did not consider the ratoon rice to be worth harvesting, as the yields were extremely low. In years when it was harvested, the largest share went to the hired harvest labor.

When presented with the idea of ratooning the new varieties with the expectation of a better yield, farmers responded positively. Of the twelve farmers interviewed, ten stated that they would favor the adoption of a ratoon variety rather than risking the planting of two crops of the currently available new varieties. One of the farmers stated that he would try to plant two rice crops if the onset of the wet season was very early, and plant a ratoon variety otherwise. The other farmer indicated that he could not predict his response to a ratoon variety until he had had first-hand experience with it.

During the three previous cropping seasons in the Iloilo area (1976-79), an average of over 70 percent of the rainfed lowland was planted to either rice-upland crop or rice-fallow patterns. Ratoon cropping could conceivably increase the productivity of nearly all of this land, provided that ratoon yields are sufficiently high to warrant the expenditure of labor for harvest.

A Technology Checklist

As a conclusion to this chapter, a checklist of the possible effects on the farm system of a new technology is presented (Table 5.1). The

Table 5.1. A technology checklist

Evaluation Criterion	Existing Technologies: Adopted	Existing Technologies: Unadopted		Notional Technologies			
	EMV	DSR	TPR	VEV	LMV	PSV	RAV
Resources							
Land Use Intensity	1	2	1	2	1	2	2
Labor Use	0	1	-2	1	0	1	1
Capital Use	-1	-2	-1	-1	0	0	0
Household Objectives							
Food Production	1	2	2	2	1	2	2
Farm Income	1	1	1	1	1	1	1
Timeliness	1	1	1	1	0	1	1
Institutions							
New Inputs or Policies	-1	-1	-1	-1	-1	-1	-1
Market Changes	-1	-1	-1	-1	1	-1	-1
Management							
New Techniques	1	-1	-1	1	1	-1	1
Critical Timing	0	-2	-1	1	0	1	1
Level of Risk	1	-2	1	1	1	1	2
Agroclimate							
Biological Feasibility	1	1	1	0	0	0	1
Climatic Fit	1	-2	1	1	1	1	2
Farmer Evaluation							
Acceptable	1	-2	-1	1	1	0	2
Foreseen Problems	-1	-1	-1	1	1	1	1

Headings: EMV - Early Maturing Variety, DSR - Dry Seed Rice, TPR - Transplanted Second Crop, VEV - Very Early Maturing Variety, LMV - Late Maturing Variety, PSV - Early Maturing Photosensitive Variety, RAV - Ratoon Variety.

Code:
- 2(-2) - Strong favorable (unfavorable) effect in comparison to traditional technology.
- 1(-1) - Favorable (unfavorable) effect in comparison to traditional technology.
- 0 - Neutral or unknown effect.

checklist is by no means exhaustive either in terms of evaluation criteria or possible technological changes. However, care was taken to select only those notional technologies which appeared to have a reasonable change of success if they could be fully developed by plant scientists and agronomists. Each existing and notional technology is rated in terms of what changes in the farm system are necessary in order to facilitate the adoption of the technology and what likely effects the successful implementation of each technology would have on the farm system in question.

Each of the four notional technologies described is designed to alleviate at least one system constraint without aggravating other constraints or creating new ones. The utilization of very early maturing varieties (VEVs) would allow the double cropping of rice with a reduced degree of yield uncertainty due to adverse climatic conditions. For land with low double cropping potential, the planting of a higher yielding, medium to late maturing variety (LMV) can increase land productivity if new late maturing varieties can be found which achieve significantly higher and more stable yield levels than the EMVs. The third notional technology suggested was the utilization of an early maturing photoperiod sensitive variety (PSV) as a complement to dry seeded crop establishment. Such a variety would contribute to the alleviation of some of the problems plaguing farmers who have tried DSR. Lastly, the utilization of rice regenerative ability through the development of a vigorous ratooning variety (RAV) was suggested as a means of increasing rice production with a small investment in areas where double rice cropping is infeasible due to high drought probabilites or other constraints.

Technology Rankings

As demonstrated in the technology checklist (Table 5.1), notional and existing technologies possess different advantages and disadvantages in terms of their adaptability to rainfed farming systems. Before technology development should take place, a ranking of technologies would be desirable so that researchers could focus on inventing the better ones. Therefore, each technology was assigned a numerical rating according to whether it possessed favorable, neutral or unfavorable effects when compared to traditional technology for each of the evaluation criteria. The summation of positive, negative and zero ratings provided on overall desirability index for each technology (Table 5.2).

Table 5.2. Technology ranking according to evaluation criteria

Rank	Technology	Overall Score
1	Ratoon Variety (RAV)	15
2	Very Early Maturing Variety (VEV)	10
3	Late Maturing Variety (LMV)	8
4	Early Maturing Photosensitive Variety(PSV)	8
5	Early Maturing Variety (EMV)	5
6	Transplanted Second Crop (TPR)	-1
7	Dry Seeded Rice (DSR)	-6

All of the evaluation criteria were weighted equally. It is likely, however that the relative weights of each criterion would vary from farm to farm depending upon such individual characteristics as land, labor and capital availability and risk preferences. Though different weights would change the individual scores for each technology, there is sufficient difference in the scores obtained by most of them that the ordinal rankings would still be likely to hold.

According to the criteria used in technology evaluation, all of the notional technologies would be superior to any of the existing new technologies. However, not all of the notional technologies would be equally desirable or beneficial in the Iloilo context. Based upon the rankings presented, it would appear that the development of an early maturing, non-photoperiod sensitive variety with a vigorous ratooning capability would best serve the needs and conditions of Iloilo farmers. From the farmers' viewpoint however, no one technology can be considered appropriate for all situations. Under current agroclimatic and socioeconomic conditions, it appears that double rice cropping is feasible mainly in the lower landscape positions with heavy clay soils which easily retain moisture. Labor and power contraints also limit the amount of land per farm that can be multiple cropped. In order to further increase the productivity of small farms, it is desirable to present farmers with a set of alternative technologies which are appropriate for different socioeconomic and agroclimatic situations. Priority should be given to the development of the most flexible technologies, i.e. those which are appropriate under the greatest number of circumstances. In the following chapter, one such technology will be formally evaluated in order to test its potential effect on the farm system and to derive minimal performance standards which can be used as guidelines for further technological development.

CHAPTER 6

AN EX-ANTE ANALYSIS OF A NOTIONAL NEW TECHNOLOGY

Analysis and evaluation of notional technologies is undertaken primarily to provide information to decision makers responsible for allocating resources to technological development. The required characteristics of a new technology must be described and, to the extent possible, quantified in order to establish clearly defined research goals. An additional purpose of analysis is to establish to what extent the existence of a new technology can improve the welfare of the ultimate target population.

In this chapter, an analysis of one notional new technology, ratoon rice cropping, will be presented as an example of the techniques that can be used to test technologies for their suitability in a specific farming system context. This will be done by devising a linear programming model incorporating the salient features of the current small farm rice production system in Iloilo, and conducting tests using the model to determine likely outcomes when the new technology is included in the set of technologies currently available to farmers. Since ratoon technology has not yet been developed, parametric programmig techniques are used to aid in the determination of certain technological parameters.

Model Domain

In Chapter 3, the basic small farm production system in Iloilo was described using flowcharts as expository tools. No attempt was made to develop a computerized simulation model of the decision-making processes described in the flowcharts. The nature of the farm system and the specificity of the technology being examined made it feasible to analyze the ratoon rice technology using a linear programming model focusing solely on rice.

Only those activities specifically connected with rice production were explicitly included in the computer model. In Chapter 2 (Figure 2.1), it was noted that rice grows during that period of the cropping season when practically no other types of crops can be grown. The competition for land use between rice and other crops is minimal, limited generally to brief periods before and after the monsoon months (generally May - November).[1/] Therefore, the specific inclusion of upland cropping activities in a formal model would make the modeling process much more difficult and complicated, while contributing little or nothing to the resolution of the problem being studied.

Farm families in Iloilo engage in non-farm and off-farm activities to the extent that labor resources are available. However, the principal means of livelihood of the majority of the families interviewed is rice production. For them rice is a staple, a principal source of cash, and a means for repaying production and consumption loans. Eleven of the twelve farm families providing information for this study stated that rice farming was their primary occupation, and that other remunerative activities were undertaken in order to supplement incomes from rice production.

1/ The actual length of time each year that rice and upland crops are competitive varies according to the particular rainfall pattern and the flooding capacity of the land.

None of the families considered that off-farm and non-farm activities restrict the amount of time available for the performance of rice production-related tasks.[2/] Therefore, it was considered unnecessary to explicitly include non-farm activities in the formal model.

The nature of ratoon technology strengthens the argument against the inclusion of other activities in the model. It uses land that would likely otherwise stand idle; it requires no cash outlays for seed or fertilizer; and only hired labor is required for harvesting. Since few resources are required, it is quite unlikely that ratooning will be rejected due to external limitations placed upon them. The problem then reduces to an examination of whether ratooning is competitive with the other means of rice production which farmers have at their disposal.

Model Selection

The criteria for the selection of an appropriate quantitative model were:

1) That the model be able to encompass the critical aspects of the Iloilo small farm system;
2) That the modelling technique be known and understood by decision makers and researchers in other disciplines;
3) That the model be able to produce answers to, or insights into, questions that could not easily be answered intuitively;

2/ In a survey of 38 farmers in the study area, Roxas et. al. (1978) reported that only four of the farmers interviewed considered non-farm work as a factor limiting rice production.

4) That the model be fairly simple computationally so that it can be adapted for use in varying situations should the need arise; and

5) That the modelling process be efficient. The value of the information generated by the model must exceed the cost of building and running the model, and no alternative model can provide the same quality of information at less expense.

A number of analytical techniques were examined using Anderson, et. al. (1977) as the principal reference. While recognizing that the actual managerial decision making process is sequential and subject to stochastic variability, methods for developing models which explicitly incorporate those features are quite complicated. For this study, a simpler methodology was deemed sufficient.

Of all the modelling techniques reviewed, linear programming seemed most appropriate in terms of the previously mentioned selection criteria. It is a technique for whole-farm analysis which, despite certain limitations, is suitable for modeling and analyzing farms with varied characteristics. The method has been widely used in determining the optimal allocation of limited resources among specific economic activities. Early applications focused mainly on large commercial farms in developed countries, though it is increasingly being used to study semi-subsistence and subsistence type farms in less developed countries (Hardaker, 1979). The technique was also used by visiting economists at the International Rice Research Institute as an aid in measuring the economic benefits of existing new technologies to small rice farmers (Barlow, et. al. 1979).

A number of packaged routines are available for carrying out linear programming analysis.[3/] Therefore, the operational difficulties of the method are limited to collecting and assembling data in an appropriate matrix format.

Determining the efficiency of a modelling technique is somewhat difficult, especially with regard to the measurement of the value of the model output. Perhaps this valuation should be carried out not by the modeller, but by those for whom the information is being provided. The case for the use of linear programming relative to other modelling techniques is strong. Normally, the input and output coefficients must be uniquely specified, so that model outcomes are generated under conditions of perfect knowledge and perfect foresight. While this is a gross abstraction from reality, it has yet to be proven that models designed to explicitly account for uncertainty, such as stochastic programming or linear risk programming, provide markedly improved results. The results of the comparison of mathematical techniques of accounting for risk and uncertainty with risk neutral models of rice production in the Philippines were inconclusive as to whether or not small rice farmers are in fact risk averse (Roumasset, 1976). The conclusion is that many observations explained through an appeal to risk aversion can be explained equally well by the type of model which explicitly incorporates the relevant details of production and consumption rather than submerging them in a utility function (Roumasset, 1979). More expensive models are not likely to improve

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3/ The model developed for the analysis used the MPSX package on the IBM 370 computer at the University of the Philippines. The model was subsequently revised and run, using the same input data format, with the APEX III program available on the CDC 6500 computer at Michigan State University.

the quality or validity of the results derivable from linear programming. Therefore, from an efficiency stand point, the use of linear programming seems justified.

Model Description

In matrix notation, the model developed here can be written as:

$$\text{Maximize } y = cx$$
$$\text{subject to } Ax \leq b$$
$$\text{and } x \geq 0$$

where:

y = the return from rice production activities above variable production costs

c = a row vector of returns above variable costs from unit levels of the available activities

x = a column vector of activity levels

A = a matrix of input coefficients for unit levels of each activity

b = a column vector of right hand side values for the constraints.

A representation of the linear programming model matrix is presented in Figure 6.1. Most activities in the actual model represent either exising or notional technologies for rice production.

Structure of the linear programming model

The model covers the period of one calendar year. Most intensive rice cropping activities are undertaken during late April through early

Activities / Constraints	WSRSS	WSRPL	RATSS	RATPL	CONSRICE	SELLRICE	USESS	USEPL	USELAB1	USECARAB	USELAB2	USECASH	NETCASH	RHS
	Ha	Ha	Ha	Ha	Ton	Ton	Ha	Ha	Days	Days	Days	$	$	
OBJECTIVE FUNCTION	-c	-c	-c	-c	-c	c							c	
Sideslope 1	1		1											≤ b
Sideslope 2	1		1											≤ b
⋮														
Sideslope 16	1		1											≤ b
⋮														
Sideslope 28	1													≤ b
Plain 1		1		1										≤ b
Plain 2		1		1										≤ b
⋮														
Plain 16		1		1										≤ b
⋮														
Plain 28		1												≤ b
1 Labor 1	a	a	a	a										≤ b
1 Labor 2	a	a	a	a										≤ b
⋮														
1 Labor 16	a	a	a	a										≤ b
⋮														
1 Labor 28	a	a												≤ b
Carabao 1	a	a	a	a										≤ b
Carabao 2	a	a	a	a										≤ b
⋮														
Carabao 16	a	a	a	a										≤ b
⋮														
Carabao 28	a	a												≤ b
2 Labor 1	a	a	a	a										≤ b
2 Labor 2	a	a	a	a										≤ b
⋮														
2 Labor 16	a	a	a	a										≤ b
⋮														
2 Labor 28	a	a												≤ b
Total Sideslope	1		1				-1							= 0
Total Plain		1		1				-1						= 0
Total 1 Labor	Σa	Σa	Σa	Σa					-1					= 0
Total Carabao	Σa	Σa	Σa	Σa						-1				= 0
Total 2 Labor	Σa	Σa	Σa	Σa							-1			= 0
Rice Inventory	-a	-a	-a	-a	1	1								= 0
Cash Supply	a	a	a	a										≤ Initial Cash
Net Cash	a	a	a	a		-a							1	= 0
Min. Consumption					1									≥ Min Cons.+Seed
Total Cash	a	a	a	a								-1		= 0

Note: a = coefficient other than one, zero, or minus one

Figure 6.1 Summary Tableau of the Linear Programming Model

November. In order to properly capture the effects of the labor constraints and yield variation over time, the span of time in which land preparation and planting activities could take place was divided into 28 weekly periods (Table 6.1). The remaining 2 periods, 1 and 30, contained 16 and 8 weeks respectively. This partitioning arrangement does not imply that no rice cropping activities can take place in periods 1 or 30. However, the intensity with which rice production activities occur is greatly reduced, thus reducing the chance that any of the constraints would become binding.

The activity set. Each activity vector included under the rice production column represents a catalog of the recorded inputs and outputs by period of a unit land area (one hectare). There are two types of rice production activities included in the model, one representing the use of early maturity varieties (existing technology) and the other a non-photoperiod sensitive variety with vigorous ratooning capability.

A sample EMV vector is shown in Table 6.2. During the first weekly period that a farmer deems appropriate, land preparation begins. After waiting a week for weed seedlings to germinate, land preparation and seeding are undertaken in the third period. During the fifth period, fertilizer is applied. From the seventh through ninth periods, crop management activities such as hand weeding, pesticide application and replanting take place. During the nineteenth period, the crop matures and can be harvested. In the LP model, there were a total of 56 activity vectors for early maturing wet seeded rice, 28 each for planting on plain or sideslope landscaped positions. Each vector for each landscape

Table 6.1. Model activity periods and dates

Period No.	Week No.	Dates
1	1-16	1 Jan - 22 Apr
2	17	23 - 29 Apr
3	18	30 Apr - 6 May
4	19	7 - 13 May
5	20	14 - 20 May
6	21	21 - 27 May
7	22	28 May - 3 Jun
8	23	3 - 10 Jun
9	24	11 - 17 Jun
10	25	18 - 24 Jun
11	26	25 Jun - 1 Jul
12	27	2 - 8 Jul
13	28	9 - 15 Jul
14	29	16 - 22 Jul
15	30	23 - 29 Jul
16	31	30 Jul - 5 Aug
17	32	6 - 12 Aug
18	33	13 - 19 Aug
19	34	20 - 26 Aug
20	35	27 Aug - 2 Sep
21	36	3 - 9 Sep
22	37	10 - 16 Sep
23	38	17 - 23 Sep
24	39	24 - 30 Sep
25	40	1 - 7 Oct
26	41	8 - 14 Oct
27	42	15 - 21 Oct
28	43	22 - 28 Oct
29	44	29 Oct - 4 Nov
30	45-52	5 Nov - 31 Dec

Table 6.2. An activity vector for a wet seeded early maturing rice crop planted before mid-August.[a/]

Period	Operation	Labor Type	Days/ha Man	Days/ha Animal
1	Land preparation	1	10.5	9.0
3	Land preparation	1	10.5	9.0
3	Seeding	2	2.1	
5	Fertilizer applicattion	2	2.7	
7-9	Hand weeding	2		
7-9	Pesticide applicattion	2	14.7	
7-9	Replanting	2		
19	Harvest-Post harvest	3	b/	

	tons/ha	$/ha
Yield	3.0	
Yield (net of harvest share)	2.5	
Cash cost		27.2

a/ Before mid-August, yield is constant at 3.0 t/ha. After mid-August, yield varies according to figures presented in Tables 6.5 and 6.6

b/ Assumed to be carried out entirely by hired labor, with the cost to the farmer being a one-sixth share of gross production.

position is identical except for the periods in which crop operations take place (Table 6.3). The first activity vector begins in Period 2 and ends in Period 20; the second vector begins in Period 3 and ends in Period 21, and so on.

The activity vectors after mid-August (Vector 18 and following) have slightly altered timing arrangements, reduced labor input requirements, and varying yield values. The altered timing arrangement involves a reduction in the number of weeks required for land preparation from three to two (Table 6.3). This change was made in order to reflect farmers' actions when planting rice late in the wet season when rainfall intensity begins to decline. Since time becomes such a critical factor, farmers tend to spend less time performing land preparation-related tasks.[4/] Average times spent on other rice production activities are also reduced late in the season. This is likely a function of reduced yield expectations, with a consequent decline in the perceived marginal value productivity of labor.

The remaining difference between rice production activity vectors occurring before and after mid-August is in relation to output. As mentioned previously, as the frequency and intensity of rainfall changes, so do expected yields. Information on yield changes as a function of rainfall variation and landscape position generated by on-farm research trials was incorporated into the late season activity vectors. Details on the yield assumptions are provided in a later section.

4/ It is also possible that crops planted late in the season may follow previously planted crops. In such instances, the land is usually already puddled, fairly weed free, and therefore easier to prepare for subsequent planting.

Table 6.3. Composition of wet seeded early maturing rice crop activity vectors on one landscape position.

		Vectors				
Periods		1	2	3 - - - - -	18 - - -	28 - -
Year 1	1					
	2	L				
	3		L			
	4	L,S		L		
	5		L,S			
	6	F		L,S		
	7		F			
	8	M		F		
	9	M	M			
	10	M	M	M		
	11		M	M		
	12			M		
	:					
	19				L	
	20	H			L,S	
	21		H			
	22			H	F	
	:					
	24				M	
	25				M	
	26				M	
	:					
	29					L
	30				H	L,S,F,M
Year 2	1					H

L = Land Preparation
S = Seeding
F = Fertilizer application
M = Management (Weeding, Pesticide Application, Replanting)
H = Harvest

So far, reference has been made only to those activities which describe the Iloilo farmers' current technology opportunity set for rice production.[5/] Those vectors provide for the selection of either a single or double rice cropping pattern using early maturing varieties on all suitable lowland fields. Another set of activity vectors was developed to encompass the notional new technology to be tested, i.e. the ratooning of a planted crop in order to obtain a subsequent harvest without the need for replanting. The ratoon vectors are similar in structure to the wet seeded EMV vectors in all respects except that an additional harvest is undertaken eight weeks after the harvest of the main crop. Fewer ratoon vectors were included than EMV vectors, due to the fact that a full main-ratoon crop sequence takes eight weeks longer. Therefore, ratoon crops planted after mid-August would have to be harvested too far into the dry season and probably would not produce reasonable yields.

The remaining activities, specified as column headings in Figure 6.1, are included for the year end accounting of resources used and constraints met. They account for rice consumed and sold, and other resources used (labor, land, power and cash) in cropping activities. Borrowing activities were not included in the model since small farmers rarely engage in formal borrowing from banks or other lending organisms. The informal community resource system is used somewhat more extensively. Farmers lacking sufficient resources can generally borrow from relatives or friends, with

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5/ The technology set included in the model is not exhaustive. It does, however, represent the technology currently used by the majority of Iloilo farmers. The adoption of traditional varieties and alternative planting methods is either declining or not increasing. The reasons for not including other existing technologies are presented in Chapter 5.

the loan repayable in kind (rough rice) at an effective interest rate approaching 50 percent. Borrowing is generally limited to small amounts, and takes place for consumption as well as production. There is, however, a distinction between consumption borrowing and production borrowing in that the interest rate for consumption borrowing is generally zero or very low. Therefore, farmers tend to avoid production borrowing and to maintain sufficient good will so that consumption borrowing is possible when necessary.

Since the technology being tested requires no more cash resources than those currently being utilized for rice production, it seemed that including lending and borrowing activities in the model would increase its complexity without a corresponding increase in predictive power. Therefore, no provisions were included in the model for borrowing activities.

Estimation of Model Coefficients

Output coefficients

Yields. The crucial coefficient in the model is that of yield. It is often the measuring stick by which farmers judge the performance of the new varieties and technologies and the goodness and badness of the outcome of any given crop season. Yield also greatly influences economic returns to the cropping enterprises.

In Appendix A, there is an extensive discussion on the effects of rainfall and landscape position on the yields of rice crops, using data generated in research trials on farmers' fields. The data do not, however, provide very precise information regarding the relationship between yield and planting date. Controlled agronomic experiments carried out by Cropping System Program researchers[6/] in the Iloilo area were used to help determine the effects of landscape position on the yields of rice crops planted late in the cropping season. The results of these experiments are presented in Table 6.4. The range of planting dates represents the stage of the crop year when second rice crops would normally be planted. The dates and yield values given, however, are not appropriate for direct incorporation into the linear programming model for two reasons. First, the method of crop establishment used for the experiments was transplanting, a technology becoming less and less popular with Iloilo farmers (Figure 3.6). The dates given in Table 6.4 are transplanting dates rather than seeding dates. Since the planting technique incorporated into the model is wet seeding, it was necessary to adjust the data so that they correspond to the date the seed is sown in the field. Rice is normally transplanted between 15 and 45 days after seeding, with an average of about 30 days. Therefore, the relationships between sowing date and yield shown in Table 6.4 were advanced 30 days from the dates given. For example, a rice crop transplanted on September 1 was assumed to be equivalent to a crop wet seeded on August 1. Second, because the experiments were managed by researchers, they received greater labor and capital inputs than farmers normally employ and produce higher yields than those that could reasonably be expected to occur on farmers' fields.

6/ The experiments were performed as part of the doctoral dissertation work of Frank Bolton, Research Fellow in the IRRI Multiple Cropping Department. His help in developing the theoretical and practical concepts presented here is gratefully acknowledged.

Table 6.4. Grain yield for the second rice crop on sideslope and plain landscape positions, by transplanting date. Iloilo, 1978-79 Crop Year.

Planting Date	Grain Yield (t/ha)[a] Sideslope	Plain
1 September	3.4	4.2
15 September	2.9[b]	3.2[b]
2 October	2.8	4.0
14 October	2.5	5.0
18 October	2.3	4.2
4 November	1.9	4.0
12 November	0.7	2.5
30 November	0.0	0.0

a/ Average of four plots with four distinct levels of nitrogen application (0, 30, 60, 90 kg N/ha).

b/ Transplanted seedlings were severely damaged due to flooding, probably accounting for a significant yield reduction.

Source: F.R. Bolton, personal communication.

After consultations with IRRI agronomists, the yield figures were adjusted down to levels which were more realistic in terms of what could be expected under normal management conditions. There were also unusual events that occurred, such as excessive flooding in mid-September, which caused substantial yield reduction. Some smoothing of the data was undertaken in order to eliminate the effects of unusual events while reflecting the underlying rainfall-yield relationship as reflected in variation of the planting date.

The data presented in Table 6.4 were used as a guide in judgmentally deriving synthetic data for different lengths of the rice-growing season. The rice yield data employed in the model, by week of planting (seeding), for three rainfall situations and two landscape positions are presented in Tables 6.5 and 6.6. Agronomists and Cropping Systems Program researchers in other disciplines agreed that these data reflect a rainfall-yield relationship consistent with empirical observation and generally accepted theoretical concepts.[7/] Analysis of the data presented in Appendix Tables A.3 and A.4 did not provide evidence for yield differentiation according to landscape position for rice crops planted during the first half of the wet season. Therefore, the base yield for all crops planted during or prior to the first week of August (Week 32) was set at a constant level. After Week 32, yields vary according to landscape position and the pattern of rainfall prevalent during the latter part of the rice cropping season.

7/ A theoretical explanation for the observed rainfall-yield responses is contained in Appendix D.

Table 6.5. Model coefficients for rice yield by planting date for three rainfall termination situations. Sideslope landscape position.

Planting Week	Rainfall Termination Situation Early	Intermediate	Late
		Yield (t/ha)	
19 - 32	3.0	3.0	3.0
33	2.8	2.9	3.0
34	2.6	2.9	3.0
35	2.4	2.8	2.9
36	2.1	2.7	2.9
37	1.9	2.5	2.8
38	1.6	2.4	2.7
39	1.3	2.2	2.6
40	1.0	2.0	2.4
41	0.7	1.7	2.3
42	0.4	1.5	2.1
43	0.0	1.2	1.8
44	0.0	0.9	1.6
45	0.0	0.6	1.4

Table 6.6. Model coefficients for rice yield by planting date for three rainfall termination situations. Plain landscape position.

Planting Week	Rainfall Termination Situation		
	Early	Intermediate	Late
		Yield (t/ha)	
19 - 32	3.0	3.0	3.0
33	3.1	3.2	3.2
34	3.2	3.4	3.5
35	3.2	3.5	3.7
36	3.1	3.4	3.8
37	2.9	3.3	3.7
38	2.5	3.1	3.7
39	2.2	2.9	3.6
40	1.8	2.7	3.5
41	1.4	2.4	3.4
42	1.0	2.1	3.2
43	0.6	1.8	3.0
44	0.0	1.5	2.8
45	0.0	1.3	2.6

There is also year to year variation in rainfall intensity at the beginning of the rice cropping season. In order to reflect this variability in the model, the week in which moisture accumulation is sufficient to allow land preparation to begin is varied according to whether the initiation of the rainy season occurred at an early, intermediate or late date. The amount of time differentiating each situation is set at one month. When the rainy season begins early, land preparation can begin in Period 2. The intermediate and late onsets of rainfall allow activities to begin in Periods 6 and 10, respectively.

Unfortunately, no systematic study of yield effects under various rainfall situations at the beginning of the rice cropping season has been undertaken. Fields planted early in the season would be subjected to drought or flood conditions during the initial stages of plant growth with a greater likelihood than fields planted later when rainfall variability is less. It is known, however, that stresses on young plants generally have a much smaller yield effect than do stresses occurring during the later stages of the growth cycle because young plants are more vigorous and stand a better chance of recovery. Therefore, the potential yield level of crops planted early in the season was assumed to be the same as that for crops planted later in the season (before Period 17).

With three rainfall situation possibilities each for both the beginning and end of the rice growing season, a total of nine possible patterns emerge.

Early onset - Early termination	(EE)
Early onset - Intermediate termination	(EI)
Early onset - Late termination	(EL)
Intermediate onset - Early termination	(IE)
Intermediate onset - Intermediate termination	(II)
Intermediate onset - Late termination	(IL)
Late onset - Early termination	(LE)
Late onset - Intermediate termination	(LI)
Late onset - Late termination	(LL)

Not all patterns are functionally distinct. For example, the EE, II and LL patterns are similar in length of growing season, the only difference appearing as horizontal shifts in the yield curves. The LI and IE and IL and EI patterns are also similar in overall season length. After eliminating patterns that would be expected to produce identical results, the following five distinct patterns were incorporated into the model structure: II, IE, IL, EL, and LE,

Output pricing. In theory, farmers all over the Philippines recieve a government-specified price for the rice they produce, subject to discounts for excessive moisture content, the presence of impurities, or poor grain quality. In practice, however, there is a marked seasonality in pricing. During peak harvest periods, farmers may receive as little as one-half of the quaranteed price. This is due in part to the lack of sufficient storage capacity to enable the government to buy rice from all who want to sell. When government bins fill up, farmers are forced to sell to middlemen at lower prices. The middlemen either store the rice for sale to the government at a later date, or place it directly on the retail market after milling.

In comparing technologies which produce output at different times of the year, gross and net returns fluctuate when output is valued at the current market price at the time of harvest. Therefore, in a budgeting or programming context, crop activities would be selected so that crops would tend to be planted and harvested in order to obtain the higher output prices It is doubtful, however, that market price variation is a major factor influencing the decision-making behavior of semi-subsistence farmers. When discussing rice farming, Iloilo farmers nearly always refer to the amount of physical product obtainable per unit of land rather than gross or net monetary returns. None of the farmers interviewed during the course of the study mentioned market strategy as having an appreciable influence on their cropping decisions. Climatic and labor allocation factors seemed to have the greatest influence on crop technology selection and timing. Therefore, seasonal price differences were not accounted for in the model. Output was valued at a constant price per kilogram, regardless of the date of harvest.[8/]

Input coefficients

Labor use. Land preparation, chemical application, handweeding, and harvesting and threshing are the principal labor-using activities required for rice production. The coefficients for each of the above activities

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8/ Even if seasonal price changes were to be considered explicitly in the model, the assignment of an output value according to the current market price at harvest is dubious at best. Farmers do not sell all of the produce at harvest time. Rice is highly storable, and farmers could conceivably hold surpluses for sale when prices increase, which is what some do.

were derived by averaging the time spent on each activity by record-keeping farmers in the Iloilo area. The numerical values used are given in Table 6.2.

The most labor-consuming tasks related to rice production are those undertaken as part of the harvest process - cutting, bailing, hauling, threshing, winnowing and drying. On all but the smallest and poorest farms, harvesting is carried out mainly by laborers hired from within the community or from nearby communities. The cost of the hired labor to the farmers is a share of the gross harvest, traditionally one-sixth of the total production of the harvested field.

The second most labor intensive task is land preparation. This activity is carried out typically by the male head of household with the aid of a water buffalo (carabao). All fields must be plowed, harrowed and sometimes leveled before they can be planted. A total of 21 days of human labor is required for the preparation of one hectare of land.

The remaining labor-using activities include handweeding, the broadcasting of seed and fertilizer and the application of chemicals to control insects. The timing and amounts of labor required for these tasks are given in Table 6.2. In general, the amount of labor spent on handweeding and chemical application is quite variable from farm to farm and from field to field on the same farm. One reason for this is that weeds and insects do not occur evenly over a field or among fields. Some areas may be heavily infested while other areas even in the same field are relatively weed and pest free. Both thorough land preparation and good water control can be effective means for controlling weeds. In a rainfed environment, however, effective water control is difficult. Handweeding is employed as a backup measure as the need arises. Prophylactic pest control measures, such as preventative insecticide spraying, are not commonly practiced by Iloilo farmers. Pest infestations are thought to be a random occurrence. Measures are taken to control insects only when they are detected and determined to be a problem.

There is also a good deal of variation as to the timing of non-critical tasks such as handweeding. There is sufficient flexibility such that weeding labor requirements may be spread out over several periods when other more critical tasks must be carried out. In order to ensure that weeding labor would not be a binding constraint, the labor requirement was spread evenly over a three week interval during the middle of the crop growth period. In contrast to weeding, the timing of such tasks as seeding and application of chemicals is somewhat critical. However, the amount of labor such tasks normally require is minimal.

Cash use. Iloilo farmers utilize cash and credit mainly to obtain material inputs necessary for rice production. The bulk of the cash expenditure (approximately 90 percent) is used for purchase of fertilizer. Other direct cash costs include expenditures for pesticides or herbicides. In the costs and returns analyses performed by researchers in the Cropping Systems Economics Section, seeds were counted as a cash cost, valued at the current market price for certified seed grain. However, purchase of rice seed by small farmers is very rare.[9/] Instead, a portion of the

9/ Most seed purchases occurred when farmers switched varieties, an increasingly common phenomenon due to the propagation by IRRI of many new lines. The quantities purchased, however, were generally small. The purchased seed is used for trial planting on small plots, to be harvested and used as seed for further planting if the farmer is pleased with the new variety. Payment for seed is normally made in kind, at harvest time, rather than in cash.

previous year's harvest is normally set aside as seed for subsequent planting. Therefore, seed acquisition is accounted for in the model as originating from stored reserves rather than as an item requiring cash.

Information gathered from daily records kept by the 12 farmers provided the figures for the cash expenditure requirement. The average per hectare cash expenditure for 33 fields of wet-seeded rice was $29.50. Material input expenditures for sideslope plots were somewhat less than for plots in the plain and plateau positions ($20.80 vs $33.80). This is probably due to differences in farmers' yield expectations for fields in different landscape positions. The probabilities of yield loss due to drought stress are higher in the upper landscape positions especially during the latter half of the growing season, and thus farmers are willing to risk smaller quantities of inputs. Sideslope fields are commonly planted later in the season after the plain and plateau fields are prepared and planted. This is due to one of two reasons:

1. A sideslope plot may have been planted with an upland crop (usually corn) before the onset of heavy rains, and thus not be ready for harvest until late in the rice planting season; or
2. Farmers want to maximize their opportunity for planting two rice crops on the lower fields, and hence plow and plant them first.

As noted in the previous section and in Appendix D, the yields of rice fields planted on the sideslope after the second week of August begin to decline. These assumptions, however, are based upon changes in weather patterns (rainfall and solar radiation) rather than on differences in the amounts of material inputs being used. Unfortunately, the data available do not provide sufficient information to account for the interaction between input levels and landscape or time of planting in other than a very arbitrary fashion. Therefore, for purposes of the model it was assumed that farmers purchased average quantities of inputs regardless of landscape position or time of planting.

Resource availability

This section contains a discussion of the limitations set on land, labor, and power production for two resource situations.

1. Four-member family, small land area (SMFM)
2. Four-member family, large land area (LGFM)

The family size and land resource characteristics were selected not on the basis of averages, but rather closely represent two actual farms which were included in the intervewing and record-keeping process. This method of presentation was selected in order to test the benefits of new technology on farms with different land resource endowments. Family size, as a proxy for labor resource potential, was judged to be a much less important variable. This is due mainly to the fact that the family labor requirements for rice production are unlikely to tax the supply of labor except for land preparation.

Labor and Power. Labor-using activities for rice production can be classified into three categories: land preparation labor (Type 1), crop maintenance labor (Type 2) and harvest/post harvest labor (Type 3). Since each labor type carries different requirements for the use of family or hired labor, the right-hand side values were determined separately by labor type.

Because man and animal labor are complementary inputs to land preparation (Labor 1), the supply of human labor is constrained by animal labor availability. In addition, the person preparing the field also performs related tasks, such as maintenance and repair of dykes and levees, without the animal. The supply of labor for Type 1 activities is limited to the amount of time that the male head of household can work. The same is true for the power supply, assumed to be one water buffalo per family.

The amount of time a buffalo can spend undertaking work activities is six hours per day, six days per week. This reflects farmers' beliefs that their animals would become ill if worked long periods without rest. A man, on the other hand, is assumed to be able to work up to seven days per week (eight hours per day).

There is no provision in the model for the hiring of draft power from the community resource pool. This restriction is included because there does not exist a supply of excess animal power from which to draw when it is needed most. When the soil is sufficiently moist for field preparation, all farmers in the area begin land preparation simultaneously. During the initial planting season, then, draft power for hire is generally unavailable.[10/]

10/ There are exceptions to this rule. For example, some farmers with very small rice plots use cattle for draft power rather than the stronger water buffalo. This type of activity was not considered widespread enough to merit explicit inclusion in the model.

Type 2 labor tasks include the broadcasting of seed or fertilizer, spraying of insecticides or herbicides, and handweeding. Each of these tasks is performed individually with the appropriate tool and, with the possible exception of spraying, can be undertaken by any member of the family of working age. There were no criteria established for differentiating the working capacity of men from women or children. It is common that family workers perform tasks for which they are best suited. For example, women and children are most commonly employed as weeders, while older boys and men carry out tasks such as spraying which requires greater strength and stamina.

There are four members of each family working the representative farms. The family running the smaller farm (SMFM) is composed of one adult male, one adult female and two children under seven years of age. The large farm family (LGFM) also has one adult male, one adult female and two children. One of the children, however is age 12 and therefore is able to contribute productive labor part time. The supply of Type 2 labor for the LGFM family is 2.5 man equivalents[11/] or a total of 18 days per week. The SMFM labor supply is 2 man-equivalents or 14 days per week.

Type 3 labor is utilized exclusively for harvest and post-harvest tasks and is performed even on the smallest farms by laborers hired from within the community. In the model, harvest labor was accounted for by reducing the amount of rice (yield) received by the farmer by one-sixth, the normal payment made to non-family harvest labor.

11/ A man-equivalent reflects the amount of time (days) one man can work in one week.

Cash. Farmers obtain cash to purchase inputs from receipts on sales of crops, off-farm and non-farm wage labor and to a limited extent through formal and informal credit markets. Since the single period model is not set up to examine alternative cash-generating enterprises such as wage labor and other non-rice farm activities, the model farm is exogenously supplied with sufficient cash to cover expenses for two crops of rice on all available land. This provided the opportunity for double cropping without a cash constraint. Cash was, however, included in the model as a means of determining the amount actually used.

Land. For purposes of the model, two land types are assumed to be functionally distinct. The first is called sideslope, which includes fields in the sideslope and upper plateau landscape positions. The second is called plain, and encompasses fields on the lower plateau, plain and bottomland positions. The amounts of each type of land available for SMFM and LGFM are indicated in Table 6.7, along with the other resource restrictions. Besides being functionally distinct in terms of yields, these two types are also managerially distinct. Iloilo farmers have recognized the superior potential for multiple rice cropping on their lower fields, and have given them first priority for preparation and planting as soon as soil moisture conditions permit.

Other restrictions. Based upon discussions with farmers regarding their opinion of the latest feasible date to plant rice, no rice crops were allowed to be planted after the first week in November (week 45). Farmers reasoned that any rice crop planted after that time would have little chance of producing a yield sufficient to cover the costs of production.

Table 6.7. Summary of resource availabilities for rice production

Resource	SMFM	LGFM
Labor (days/wk)a/		
Type 1 (Family)	7.0	7.0
Type 2 (Family)	14.0	18.0
Power (days/wk)b/		
Carabao	6.0	6.0
Land (ha)		
Sideslope	0.4	1.4
Plain	0.6	1.6
Cash ($)	54.4	163.2

a/ One man-day = eigth hours.

b/ One animal-day = six hours.

A minimum grain reserve requirement was specified per year. No linear programming solution could be considered realistic unless sufficient grain was produced for consumption and seed for the following year.12/ No systematic study of rice consusmption patterns was undertaken in this

12/ It is common for Iloilo farmers to reserve part of one year's harvest for next year's seed; therefore, seed was included with the consumption reserve requirement rather than as a cash cost.

study. Information contained in another study (Barlow, et. al, 1979) indicated that per capita rough rice consumption levels vary from 150 to 250 kilograms per year. The reserve for consumption was arbitrarily set at 800 kilograms rough rice per family. Seed requirements were found to average 75 kilograms per hectare per crop. Sufficient seed was required to be kept in the reserve in order to plant two rice crops on all suitable areas. Therefore, the total grain reserve requirements for SMFM and LGFM were set at 950 and 1250 kilograms respectively.

Model Verification and Validation

Any model should be tested in order to determine whether it adequately serves the purpose for which it is intended. One means of testing a model is checking the results to see how closely they correspond to expectations based upon prior knowledge of the farm system. Another means of model validation lies in comparing model results to the historical results of farmers' actual cropping decisions.

The verification and validation process began with the running of the model for the five rainfall cases described earlier in the chapter; II, IE, IL, El and LE. Based on information presented in Chapter 2, the following expectations were formulated:

1. More double cropping would be expected during years when the rainy season is relatively long.
2. During any given year, the effective rice growing season is longer on the lower landscape positions. Therefore, more double cropping would be expected on the plain than on the sideslope.
3. Land preparation labor and power would be the principal factors limiting the amount of land that could be planted per week.

The results of the initial runs, without the inclusion of the notional technology, are presented in Table 6.8. As the length of the rainy season increased (from LE to EL), the amount of double rice cropping entering the optimal solution also increased as expected for both SMFM and LGFM. Furthermore, the rate of increase in double cropped area on the plain was greater than on the sideslope landscape position. This also coincides with previously formulated expectations.

Table 6.8. Area planted to rice in the optimal linear programming solution, by cropping pattern, lanscape position, and farm size. Existing technology.

Rainfall Pattern	SMFM				LGFM			
	Area Double Cropped (ha)		Area Single Cropped (ha)		Area Double Cropped (ha)		Area Single Cropped (ha)	
	SS	PL	SS	PL	SS	PL	SS	PL
LE	0	0	.4	.6	0	0	1.4	1.6
IE	0	.6	.4	0	0	.8	1.4	.8
II	.4	.6	0	0	.2	1.6	1.2	0
IL	.4	.6	0	0	.2	1.6	1.2	0
EL	.4	.6	0	0	1.4	1.6	0	0

The model output was further examined to determine which of the resource constraints were binding. In general, the most constraining resources were labor and power for land preparation (Labor 1) and land of both types. Labor and power tended to constrain most during the first few periods that rice crops could be established, and during the period of possible second crop establishment. Family labor for other activities

(Labor 2) was never a binding constraint for either SMFM or LGFM. Land of both types was generally most limiting when yield levels began to rise as the end of the rainy season approached. This was indicated by the fact that the marginal value productivity of land during peak yield periods was high, signifying a high value for land at those times if it were available.

The results of the initial model runs were also compared to the historical cropping practices on the SMFM Iloilo farm for the 1977-78 and 1978-79 crop seasons (Table 6.9). During the 1977-78 crop season, most of the land in both the sideslope and plain positions was double-cropped. This strategy, also shown by the model, is appropriate for a year with a fairly long rainy season (EL). Unfortunately, the length of the 1977-78 rainy season was rather short (Appendix Figure A.2). This pattern corresponds to the short season case (LE) with a late rainfall onset and an early termination. In the LE case, the model would have selected a single rice crop pattern on both the sideslope and plain fields (Table 6.8). The actual yields of the areas planted to rice on the SMFM farm for 1977-78, according to landscope position and planting date, are given in Table 6.9.

The information contained in Table 6.9 points out a problem that was mentioned earlier. Given the rainfall pattern that occurred in 1977-78, the second rice crops yielded poorly and should probably not have been planted. However, the model was unable to correctly predict the farmer's decision-making behavior with respect to rice production. This occurred principally because the model is equipped with information upon which to base the cropping prescription that a farmer does not have access to. The model allocates resources based on certain knowledge of the future

Table 6.9. Actual rice yield obtained on the SMFM farm for 1977-78 and 1978-79, by crop and landscape position.

	1977-78		1978-79	
	Sideslope	Plain	Sideslope	Plain
First Crop				
Planting Week	28	25	33	22
Yield (t/ha)	2.2	3.8	1.9	3.2
Area (ha)	.4	.6	.4	.6
Second Crop				
Planting Week	43	43	--	41
Yield (t/ha)	.2	.7	--	2.2
Area (ha)	.3	.5	0	.5

rainfall pattern, and consequently of the rice yields that will be obtained. Had the farmer possessed ex ante knowledge of the rainfall pattern, his rice cropping decisions may have more closely coincided with those prescribed by the model.

In 1978-79 interviews with the SMFM farmer indicated that he modified his cropping strategy based upon learning that took place after the previous crop year. Though the second crop yields on both landscape positions were disappointing, the farmer realized that the main cause was lack of rainfall during the latter part of the season. Though he could not forecast the late season rainfall pattern, the best possibility for two crops was probably in the lower (plain) fields. The strategy adopted was to attempt to plant two rice crops on the plain fields, while planting only one on the sideslope. The results of the 1978-79 cropping strategy are contained in Table 6.9. As it turned out, the rainy season for 1978-79 was fairly long, roughly corresponding to either the IL or EL rainfall cases. For reasons specified previously, the model would not have correctly predicted farmer behavior.

Based on initial model runs and comparisons with historical farmer behavior, the strengths and weaknesses of the model become evident. The model prescribes cropping patterns which are logically consistent with expectations given different rainfall situations. Since it is endowed with more information than farmers possess, it cannot accurately predict farmers' decisions in the uncertain real-world environment. This factor is taken into consideration in the interpretation of model results in a later section.

Model Application

The main purpose for the construction of the linear programming model is to determine the effect the introduction of a new technology may have on rice production and farm incomes. The first step in the analytical process is to determine the minimum level of required performance so that the technology can be considered a viable alternative. The second step involves running the model under varying climatic conditions to estimate the potential benefits of the new technology. As part of this evaluation the outcome of each rainfall situation is weighted by its likelihood of ocurrence in order to obtain the expected benefit. The final step consists of the specification of likely farmer strategies designed to deal with the real-world uncertainties with which farmers must contend. The strategies are then imposed on the model to obtain somewhat more realistic outcomes.

Experiments with the model

Based upon the observed performance of rice varieties currently used by Iloilo farmers and knowledge regarding their decision-making patterns, the following characteristics of a new high-yielding ratoon variety were incorporated in the linear programming model:

1. The field duration of the main crop[13/] is similar to that of rice varieties (EMVs) currently grown in the Iloilo area;
2. The main crop yield potential is similar to that of varieties now in use; and
3. The field duration of the ratoon crop is roughly one-half the duration of the main crop.

With the preceeding as part of the model structure, initial experiments were performed in order to help determine minimum desirable yield levels for the ratoon crop.[14/] Once ratoon yields were determined and

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13/ A ratooning variety is actually two crops of rice; a main crop, which is then allowed to regenerate, producing a ratoon crop.

14/ Determining minimum yield levels for the ratoon crop is especially important as a guide in the selection and breeding of new ratoon rice varieties.

entered into the model as parameters, further experiments were undertaken to determine the likely benefits to farmers of ratoon technology under various assumptions regarding the length of the rainy season and yields.

Experiment 1 - Determination of minimum desirable ratoon yield levels.

The model, including both historical and ratoon technology vectors, was used to estimate the potential adoption of the new technology by parametrically varying ratoon yields from .25 to 1.5 tons per hectare.

Table 6.10. Percent of area ratooned under varying yield assumptions for an intermediate rainfall situation for the Small Farm (SMFM) - Model Results.

Ratoon Yield (t/ha)	Area Ratooned (%) Sideslope	Plain
.25	50	0
.50	50	0
.75	50	0
1.00	50	0
1.25	83	0
1.50	100	0

The range of ratoon yield values tested was chosen to represent a reasonable approximation of what breeders could expect to attain given the biological limitations. The results of the experiment, carried out for SMFM using the intermediate rainfall pattern (II), are presented in Table 6.10.

According to the model, 50 per cent of the sideslope area would be ratooned, even at very low yield levels. In reality, however, very low yields would not be likely to encourage farmers to ratoon. Therefore, it was judged that the minimum yield value that must be reached in order for ratoon technology to become viable lies between 1.0 and 1.25 tons per hectare. In that range, adoption of ratoon technology becomes more competitive with historical technologies including double cropping as shown by the model results (Table 6.10). For subsequent runs of the model for all rainfall situations, the ratoon yield was set at 1.0 ton per hectare.

Experiment 2 - Determining the potential benefits of ratoon technology.

In order to obtain an indication of the benefits to be expected from the introduction of ratoon technology, the model, including the ratoon activity vectors, was run for all five rainfall situations for SMFM and LGFM. The areas of new technology adoption are presented in Table 6.11.

Comparing the results in Table 6.11 with those presented in Table 6.8 (without ratoon), we find that ratoon cropping largely replaces the single rice crop pattern on both farm sizes. There is little effect on the area that can be double cropped. Also, as expected, ratooning entered the optimal solution with greatest strength during the short rainfall situations (LE and IE) on both SMFM and LGFM.

Comparisons of returns above variable cost, less the consumption requirement, with and without ratoon technology are presented in Table 6.12. In general, the net benefits of ratoon technology, in terms of added income, vary according to the prevalent rainfall situation. Ratoon

Table 6.11. Optimal rice cropping pattern for five rainfall situations on one hectare (SMFM) and three hectare (LGFM) farms - Ratoon activities included.

Rainfall Situation	SMFM a/				LGFM					
	DRC Area		Ratoon Area		DRC Area		SRC Area		Ratoon Area	
	SS	PL	SS	PL	SS	PL	SS	PL	SS	PL
LE	0	0	.4	.6	0	0	.3	1.3	1.1	.3
IE	0	.6	.4	0	0	.7	0	.3	1.4	.6
II	.2	.6	.2	0	0	1.3	0	.3	1.4	0
IL	.4	.6	0	0	.2	1.6	.3	0	.9	0
EL	.4	.6	0	0	1.4	1.6	0	0	0	0

DRC = Double Rice Crop
SRC = Single Rice Crop
a/ No single rice cropping entered the optimal solution for SMFM.

Table 6.12. Net monetary returns ($) to rice production with and without ratoon technology for two farm sizes. Model results.

Rainfall Situation	Without Ratoon	With Ratoon	Difference	Percent Increase
		SMFM ($)		
LE	193	286	+93	48.2
IE	259	302	+43	16.6
II	359	372	+13	3.6
IL	469	469	0	0
EL	531	531	0	0
		LGFM ($)		
LE	839	984	+145	17.3
IE	926	1120	+194	21.0
II	1107	1231	+124	11.2
IL	1337	1434	+ 97	7.3
EL	1707	1707	0	0

technology is quite beneficial during years with short rainy seasons (LE,IE), and of less significance when the rainy season is long (IL,EL). With regard to farm size, ratoon is most beneficial to the SMFM in the very short growing season situation, and of substantially less benefit in other rainfed situations. Largely due to labor constraints, the benefits to LGFM are distributed more evenly over four of the five rainfed situations.

Though the preceeding information is helpful, it is difficult to draw any conclusion about the general value of the technology without some indication as to the likelihood of occurrence of each rainfall situation. Historical rainfall records from the study area were gathered by CSP researchers and used to estimate a probability distribution of rainy seasons of different lengths (Zandstra and Maligalig, 1978). The cumulative probabilities of receiving 200mm of rain by a given date and of still receiving 200mm of rain after a given date for the Iloilo area are given in Figure 6.2. The rice planting season was defined to start after 200mm of rain has fallen, enabling most fields to be tilled easily and puddled for subsequent seeding. The rainy season was also defined to end with 200mm of rain yet to fall, in order to provide the possibility for planting and harvesting an upland crop during the early part of the dry season.

The range of lengths for each rainfall situation was designated as follows:

LE = 100 - 130 days
IE = 130 - 160 days
II = 160 - 190 days
IL = 190 - 220 days
EL = 200+ days

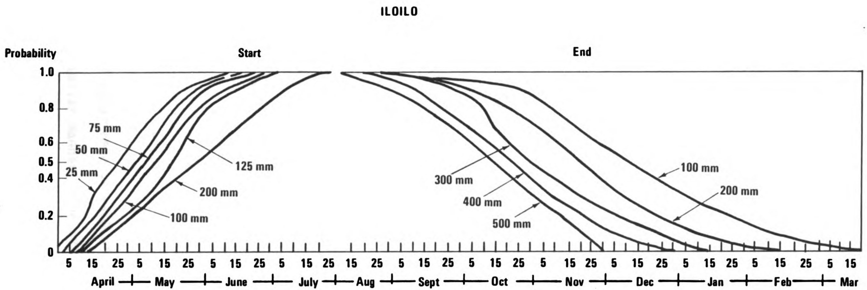

Figure 6.2. Cumulative probabilities of receiving given amount of rain on a certain date (start) and of still receiving a certain amount of rain after a given date (end) for the Iloilo rainy season (Tigbauan rainfall records).

Source: Zandstra and Maligalig, 1978.

From the cumulative probability distribution presented in Figure 6.2, the probability that the length of the rainy season will be greater than or equal to a specified number of days was estimated. This was accomplished by measuring the distance (in terms of days) between the two 200mm curves along the horizontal axis and reading the corresponding probability along the vertical axis. Letting X represent the length of the rice growing season, the following cumulative probabilities were determined:

$$P(X \geq 100 \text{ days}) = .86$$
$$P(X \geq 130 \text{ days}) = .72$$
$$P(X \geq 160 \text{ days}) = .57$$
$$P(X \geq 190 \text{ days}) = .41$$
$$P(X \geq 220 \text{ days}) = .23$$

The above information was used to calculate the probability of occurrence of each rainfall situation. Given an interval of time, bounded by w days and y days, then:

$$P(w \leq X \leq y) = P(X \geq w) - P(X \geq y)$$

For example, using the above formula, the probability of occurrence of rainfall situation LE is determined as follows:

$$\begin{aligned} P(LE) &= P(100 \leq X \leq 130) \\ &= P(X \geq 100) - P(X \geq 130) \\ &= .86 - .72 \\ &= .14 \end{aligned}$$

The probability of occurrence of each of the other rainfall situations was calculated in a similar manner. The results are listed below:

$P(IE) = .15$

$P(II) = .16$

$P(IL) = .18$

$P(EL) = .23$

The expected increase in net returns due to the new technology is determined by summing the differences in net returns with and without the new technology for each rainfall situation multiplied by the probability of occurrence of each situation. In mathematical terms,

$$E(INR) = \sum_{i=1}^{5} P(X_i)(NR_i^{nt} - NR_i^{ot})$$

where:

X_i = rainfall situation i

NR^{nt} = net return with inclusion of new technology

NR^{ot} = net return without new technology.

The expected increase in net returns due to the addition of ratoon technology availability to the model for SMFM is determined as follows:

$$E(INR) = (.14)(93) + (.15)(43) + (.16)(13) + (.18)(0) + (.23)(0)$$
$$= \$21.55$$

in a similar manner, the expected increase in net returns for LGFM was determined to be \$86.70. These figures represent expected yearly income increases of 6.5% and 8.1% for SMFM and LGFM, respectively, obtainable with the addition of ratoon technology having the characteristics specified in the model.

Accounting for uncertainty

The preceeding results demonstrate what a farmer could expect to gain on average with the addition of ratoon technology, given that he is able to perfectly forecast each year's rainfall pattern and adjust his cropping strategy accordingly. In reality, however, farmers are unable to foresee weather patterns and must make their cropping decisions based on whatever information they can accumulate. An attempt was made to determine the rice cropping strategies that Iloilo rainfed farmers would be likely to follow with the technologies they have recently acquired. This was done by interviewing several farmers who had had at least two years of experience with wet seeding early maturing rice varieties. Each farmer was asked to give his general impressions of the new technology and forecast what cropping strategies he would follow in the future. The general consensus was that the most favorable feature of the new varieties was their early maturing characteristic, thus providing the opportunity for planting more than one crop on the same land in a single growing season. Their experience indicated that double rice cropping was most likely to be successful on fields in the lower landscape position (lower plain and bottomland) while a single rice crop preceeding or following an upland crop would be best for fields in the upper landscape positions (upper plateau and sideslope).

Based upon this information, the following cropping plan was imposed on the model for all rainfall situations and for both farm sizes: planting a single rice crop on all sideslope fields and two rice crops on all plain fields.[15/] The model was rerun as before for all rainfall and farm size situations both with and without the availability of ratoon technology. The results are presented in Table 6.13. Following the procedures outlined in the previous section, the expected increase in yearly net returns due to the introduction of new technology was $37.30 for SMFM and $118.29 for LGFM. These figures represented increases in expected net returns of 13.3% for SMFM and 12.0% for LGFM.[16/]

Imposing a probable farmer strategy on the model not only makes it more realistic, but also provides a closer approximation of the levels of benefits that can be expected to occur as a result of the introduction of new technology.

Interpretation of the Model Results

The results of the modelling effort seem to indicate that the benefits of developing ratoon technology would not be extremely high, both in terms of the size of productivity increases as well as net economic benefits to small farmers. However, a problem with the model

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15/ Single rice cropping on the sideslope was imposed by deleting rice production activity vectors late in the growing season. All ratoon activities were deleted from the plain, even when ratoon technology was included as an model option.

16/ The expected benefit of ratoon technology was higher for the incertainly situation than the certainly situation due to the fact that ratoon enters the solution regardless of the rainfall pattern. Therefore, there is always a positive benefit (Table 5.13) whereas in the certainty case (Table 5.12), ratoon is of little or no additional benefit in years with a long rainy season (IL, EL).

Table 6.13 Net monetary returns ($) to rice production with and without ratoon technology for two farm sizes - Farmers' Strategy. a/

Rainfall Situation	Without Ratoon	With Ratoon	Difference	Percent Increase
		SMFM		
LE	177	221	+44	24.9
IE	259	302	+43	16.6
II	324	367	+43	13.3
IL	389	433	+44	11.3
EL	414	457	+43	10.4
		LGFM		
LE	795	940	+146	18.2
IE	904	1057	+153	16.9
II	1102	1222	+120	10.9
IL	1316	1432	+116	8.8
EL	1416	1568	+152	10.7

a/ The without ratoon strategy consisted of a single rice crop on all sideslope land and a double rice crop on all plain land. In short rainfall situations (LE and IE) when no double cropping on the plain was allowed by the model, cash costs for a second planting with zero yield were deducted from the net return. The with ratoon strategy allowed a choice between planting a single crop and ratooning on the sideslope.

becomes evident upon examining the data contained in Table 1.4. As indicated in the table, a maximum of 30 percent of the rainfed lowland fields were planted to a double rice crop pattern in the crop years for which data was available. The farm situations considered in the model were assigned mostly plain land (60 percent and 53 percent for SMFM and LGFM respectively) with a high double rice cropping potential. Had the land resource endowments incorporated in the model more closely reflected what appears to be the more general situation in Iloilo rainfed lowland areas, the benefits associated with the development and adoption of ratoon technology would have been substantially higher.

The conclusion reached, then, is that ratoon technology has a high potential for improving the productivity of Iloilo rainfed farming systems. The benefits to be realized by each individual farmer depend upon his land quality endowment and relative risk preferences. Ratoon technology would tend to benefit relatively more those farmers with poorer quality land resources and those who are relatively risk averse. In this sense, ratoon is a technology that is biased in favor of the more disadvantaged farmers, and therefore could potentially offset some of the inequalities brought on by most types of technological change, which usually are biased in favor of those who are better off to begin with.

CHAPTER 7

SUMMARY AND CONCLUDING OBSERVATIONS

Recently there has been a growing emphasis on the development and diffusion of agricultural technology in less developed countries, as a vehicle for rural development as well as for provision of basic food supplies to the rural population. A great deal of investment in agricultural research has taken place, with major expenditures made by philanthropic foundations and developed country governments to fund the international agricultural research centers (IARCs).

Partly as a product of this investment, high yielding and early maturing varieties of rice and wheat have been developed and diffused. While production technologies based on these varieties have had a large impact on total output, the derived benefits have not been distributed equitably among all producers. The technologies were developed without regard to specific sizes or types of farms. However, by choosing the types and levels of inputs and the agroclimatic conditions under which the technologies were developed, researchers in effect developed technologies appropriate for adoption by producers with command over high-quality natural resources and sufficient capital to obtain the necessary complementary inputs.

As numerous studies have since demonstrated, the technologies were much less attractive to producers lacking the required prerequisites (Morss, et al., 1976). The adopting group tended to be relatively large, well-educated and wealthy farmers, while the non-adopters tended to be small-scale, uneducated, resource poor farmers. Social scientists have spent much time and effort in ex post evaluation of the reasons why small farmers have not benefited from new agricultural technology. Recently, it has been suggested that social scientists re-direct their efforts toward ex ante analysis of small farm circumstances with the objective of contributing to the development of more appropriate rural technologies (Valdés, et al., 1979; CIMMYT, 1980).

The study described in the preceding chapters represents an attempt to demonstrate the potential role for economists working with biological scientists in the ex ante design and evaluation of technology consistent with the needs and circumstances of small farmers. Major emphasis was placed on trying to understand the farm decision-making environment and learning to identify the variables that are most often taken into consideration by farmers when making production decisions. The objectives of this chapter are to summarize the methodology and results of the study, and to present conclusions in the form of a suggested methodology for future farming systems research.

Summary of the Methodology

The methodology employed in the study consisted of five sequential research steps: (a) system exploration; (b) system conceptualization; (c) problem identification; (d) notional technology conceptualization; and (e) notional technology evaluation.

The first two steps contained the information gathering and interpretation processes. Though a large amount of quantitative data had already been gathered by IRRI Cropping Systems Program (CSP) researchers, it was necessary to collect additional information in order to achieve an adequate qualitative understanding of Iloilo rainfed farming systems.

The instruments used to collect information were informal as well as formal surveys conducted personally by the researcher. Informal surveys consisted basically of discussions with farmers to learn what their farming decisions were and the reasoning behind those decisions. The informal survey was carried out over a number of weeks and involved approximately 10 visits to each farmer in the 12 farmer sample. During this process, certain issues and types of decisions repeatedly arose, either as answers to specific questions or as tangential comments.[1/] These items were subsequently incorporated into formal surveys consisting of preformulated questions asked of all farmers participating in the study. The main purpose of the formal surveys was to confirm or refute the ideas obtained during the informal surveys.

The outcome of the survey work led to the development of the conceptual decision model presented in Chapter 3. This model represents the workings of the system as interpreted by the researcher. As such, it provided the analytical framework for use in subsequent research steps.

The third research step consisted of identifying problems which could be alleviated by the development of new technology. Both the farmers' expressed desire for increased rice production and the particular interests and talents of the CSP researchers influenced problem definition. The decision was therefore made to examine existing and potential rice-

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1/ The collection and incorporation of tangential comments into the surveys was a critical part of the learning process. This was referred to as accidental learning in Chapter 1.

production technologies which would promote increases in the productivity of Iloilo farming systems without violating the agroclimatic and socio-economic constraints faced by farmers.

The final research steps dealt with "inventing" and evaluating notional new technologies.[2/] The information gathered and incorporated in the conceptual decision model, plus existing information generated by CSP researchers, was used to subjectively derive notional (hypothetical) technologies that would likely fit into the prevalent farming system. Most of the notional technologies had their genesis in techniques either used currently by farmers or developed in previous experimental work. Ratoon cropping, for example, is a traditional farmer practice in the Dominican Republic and certain areas of India. It has not, however, been associated with the newly developed non-photoperiod-sensitive varieties. Both characteristics (ratoonability and non-photoperiod-sensitivity) are crucial for the development of a new technology for the Iloilo context.

The evaluation of notional technologies, as well as those already known by Iloilo farmers, was undertaken with two objectives in mind. The first objective was to identify technological alternatives likely to be acceptable to farmers. Existing and notional technologies were examined in Chapter 5 and evaluated according to a number of criteria in order to determine compatability with farm resource availability, household objectives, institutional realities, management capabilities and the agroclimatic environment. In addition, each technology was explained to

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2/ The use of the word "invention" here implies the generation of ideas regarding potential technologies rather than their actual development.

farmers in the sample group and their reactions were recorded. Farmer evaluation was especially important, as it provided the opportunity to detect other important performance criteria that may have been overlooked. The technologies were then given scores according to how well each met the specified performance criteria, and then ranked according to their relative desirabilities as indicated by their total scores over all criteria.[3/]

The second objective was to provide more precise information to biological scientists (especially plant breeders) regarding the desireable characteristics of new technology. To accomplish this, the highest ranking alternative technology (ratoon variety) was examined using a linear programming model which incorporated the salient features of Iloilo rainfed farming systems. Successive runs of the linear programming model provided information regarding minimum desireable ratoon yield levels and the economic benefits potentially accruing to farmers upon adoption of ratoon technology in appropriate situations.

Summary of the Results

The results of this study can be divided into three major categories: the development of conceptual models of farmers' crop selection and cultivation processes; the development of notional new technologies with potential for overcoming some of the constraints on farmers; and the

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3/ For this exercise, all criteria were weighted equally. Other weighting methods could have been used, but probably would not have significantly affected rank since there was a substantial spread among most alternatives.

evaluation of notional technology both subjectively according to specified criteria and using quantitative modelling techniques.

Farmer decision making

During the course of the field work, an attempt was made to describe the types of decisions farmers face in choosing and executing cropping activities, and to gain insights into the processes which determine the selection of one crop or cropping practice among those available. The variables that influence farmers' decision making behavior can be divided into two categories. The first consists of the general body of knowledge stemming from research in the physical, biological and social sciences. Knowledge of this type generally has a weak effect on decision making, as only those elements known well enough to be usefully interpreted will influence farming decisions.

The second category consists of factors which are experienced by farmers directly and thus play a more salient cognitive role in the decision making process. For example, a farmer may have little knowledge regarding the complex biological interactions which take place among soils, climate and plants, but through experience he does know which crop grows best on a certain field or portion of a field. Other factors such as household food requirements, the resource limitations which restrict choices of crops and technologies, and prices of crops and inputs on local markets are strongly detected by farmers and play a relatively large role in determining the cropping decisions.

The prevalent conditions on each farm, along with accumulated past experience, are translated into a set of decisions rules or patterns which govern farmer behavior. Such rules evolve over time and may change as greater experience is gained or with changes in technology or in one or more of the farm-level conditions.

As an aid in conveying the nature of typical Iloilo cropping decisions, a number of schematic models were developed, each representing the basic decision points and decision rules regarding crop selection and cultivation. The decision points depicted in each model were elicited from farmers during the informal interview process. Towards the end of the study, the models were utilized, along with other information, in the generation of notional new technologies and the criteria which were eventually used to evaluate them.

New technology evaluation

Based upon an understanding of the conditions facing Iloilo small farmers and their typical reactions to those conditions with regard to cropping activities, several notional technologies were generated. The major criterion for selecting notional technologies was that they alleviate at least one system constraint without violating others. A total of four potentially feasible technologies were envisioned, and each was evaluated along with three existing technologies according to the following criteria: (a) appropriateness to the existing limited resource base; (b) the extent to which a contribution was made to household objectives (especially timeliness of food); (c) the extent of new labor, credit or marketing requirements; (d) the managerial requirements of the technology; (e) the extent to which the technology fits prevalent climatic patterns; and (f) subjective acceptability to farmers.

The existing technologies included the use of early maturing, non-photoperiod sensitive rice varieties (EMVs), dry seeded rice (DSR) and a transplanted second rice crop (TPR). The principal advantage of EMVs in comparison to traditional varieties is that they mature much earlier in the growing season, thus increasing the potential for multiple cropping, with either rice or an upland crop being planted after the first rice crop. Moreover, EMVs allow staggered planting and harvesting, thus achieving a better distribution of labor requirements during the peak labor-use season. The major drawback of EMVs is that they require greater amounts of purchased inputs (especially nitrogen fertilizer) to reach their yield potential. Furthermore, they must be harvested during the rainy season, thus creating problems with drying and losses due to grain rotting.

The dry seeding of EMVs (DSR) is designed to improve the prospects for planting a second rice crop in areas such as Iloilo where the length of the rainy season does not usually allow the successful establishment of two consecutive rice crops using wet seeding techniques. The major drawbacks of DSR are germination and seedling death problems and excessive weed competition (in the absence of herbicides), all due to the erratic nature of rainfall early in the planting season. For these reasons, DSR was classified as a high risk technology, not acceptable to most farmers.

The final existing technology examined, transplanting the second rice crop using old seedlings (TPR), enhances the possibility of obtaining a good yield by shortening the time from harvest of the first crop to maturity of the second. The main disadvantage of TPR is related to the unavailability of labor during harvest time, given that harvest wages are typically much higher than those paid for transplanting.

A total of four notional technologies were proposed and evaluated. First, the development of a very early maturing variety (VEV) would allow the wet establishment of two rice crops in a single season by reducing the total time from planting to harvest, thus reducing the risk of yield reductions of the second crop due to drought stress. Second, given a positive relationship between maturity period and yield, late maturing varieties (LMVs) could increase rice output above current levels, eliminating the possibility of a second rice crop but maintaining the possibility of planting an upland crop after rice. Third, the invention of a photosensitive, early maturing variety (PSV) would be designed to correct one of the drawbacks of DSR, that of uneven maturation due to the presence of poor initial stands and the subsequent need for replanting if its maturity period coincided with the maturity of the plants that survived from the initial dry seeding.

The final notional technology examined was a vigorous ratoon variety (RAV) - one that fully utilizes the rice plant's regenerative ability to produce a subsequent crop from the stubble of a previous crop. The principal advantage of ratoon as a second crop is that in favorable conditions the ratoon crop begins to grow as soon as the previous crop is harvested and its maturity period is roughly half that of a planted crop. Furthermore, land preparation and planting labor requirements would be eliminated, a distinct advantage when harvest labor use is high.

As mentioned previously, the technologies, both existing as well as notional, were assigned numerical values according to how well they met each of the performance criteria and then ranked according to overall score. The highest ranking one, ratoon rice, was subjected to further evaluation by inclusion in the linear programming model.

The quantitative model

A linear programming model (LP) was developed for use as a tool in determining minimum yield performance levels, likely adoption rates (in terms of percentage of total land planted to ratoon), and the expected benefits to farmers of ratoon technology. The salient features of small farm rice production systems in the rainfed areas of Iloilo were incorporated into the model, and tests were then conducted to determine likely outcomes when the notional technology is included in the set of technologies currently available to farmers.

Linear programming was chosen as the modelling technique because it is computationally simple, well understood by decision makers and researchers in other disciplines, and able to take into account the critical aspects of the Iloilo farm systems. Furthermore, it was determined that more sophisticated techniques which better represent the sequential decision-making process would not likely provide markedly improved results which would offset the increased modelling costs.

The model itself includes the possible rice cropping activities which take place at different times over the course of a year.[4/] In order to capture the effects of labor and power constraints, as well as yield variation according to time of planting, the model was partitioned into 28 weekly periods and 2 additional periods of longer length. This also allowed rice production acitivities to be distributed throughout the season, thus providing a more realistic picture of farmers' cropping activities.

Two types of rice production activities were included in the model, one representing the wet seeding of an early-maturing variety (existing technology), and the other a variety with characteristics similar to the EMV but also possessing vigorous ratooning capability. The technical input coefficients for labor, power and purchased inputs (cash) were derived from Iloilo farm record data. A number of constraints were placed on the production activities, including family labor and power supply, land restrictions by size and type, and minimum requirements for consumption and seed for subsequent planting. The yield levels incorporated in the model reflected the low input use typical of the region, so it was unnecessary to include cash availability as a constraining factor.

Rice yields were varied according to three factors: rainfall pattern, planting date and landscape position. The planting activities could begin during any of the 18 weekly periods. Once a rice crop was established, yield then varied according to the length of the rainy season (short,

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4/ Upland crops were not incorporated into the model. They do not compete with rice, due to distinct agroclimatic environmental requirements.

medium and long). In general, the lower landscape position (plain) has a greater multiple rice crop potential than the upper position (sideslope), a fact that was reflected in the yield levels incorporated into the model.

The farm-gate price of rice varies throughout the year according to supply conditions, even though the Philippine government theoretically offers a guaranteed minimum price. A seasonal average price was used to value the output in the model because the nature of ecological conditions does not allow farmers to vary planting dates in order to harvest when output prices are highest (usually toward the end of the dry season). Furthermore, since rice is storable, the price at harvest time would not necessarily correspond to the amount actually received by farmers.

In order to detect the benefits of new technology to farms with different resource endowments, land constraints were varied to represent two situations: small land area (SMFM), and large land area (LGFM).

As a means of validation and verification, the model was tested for correspondence to logical expectations based on prior knowledge of the farm system. The results of the initial runs, incorporating various lengths of the rainy season, indicated that multiple rice crop potential increased with the length of the season and in the lower landscape position. This corresponded well with expectations.

Model results were also compared with historical cropping practices, and it was found that the model was unable to correctly predict the actual patterns adopted. This occurred due to the fact that the model was equipped with <u>ex ante</u> knowledge of the rainfall pattern, while farmers made decisions under uncertainty which did not coincide with the best outcomes ex post. This model defect was corrected later on by imposing a strategy likely to be adopted by farmers, as evidenced by both their actual behavior and opinions related during interviews.

Once the model was deemed to be reasonably accurate in terms of producing results logically consistent with expectations and historical practices, a number of experiments were conducted in an attempt to gain increased insight regarding the likely effects of the introduction of new technology on cropping practices, rice production and farm incomes. As mentioned previously, the model included the most widely adopted existing technology, wet seeded early-maturing rice, as well as ratoon, the proposed notional technology. The characteristics of ratoon technology incorporated into the model included a main crop field duration and yield potential similar to EMVs currently in use, and a field duration of the ratoon crop equal to one-half that of the main crop.

The first experiment consisted of parametrically varying yield levels of the ratoon crop in order to determine a minimum yield which would make adoption attractive to farmers, as well as being at a level potentially attainable by plant breeders. The range of yields explored was determined subjectively, both by observing yields of ratoon crops in the CSP trials, as well as through discussion with plant breeders.

The model results indicated that ratoon technology would be adopted, even at very low yields, on the sideslope land, even though at such levels it is likely that farmers would graze the land rather than harvest the rice. The adoption rate[5/] was stable from .25 to 1.0 tons per hectare,

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5/ The adoption rate reflects the percentage of land assigned to new technology by the model.

then increased significantly at the 1.25 tons per hectare level. For subsequent runs of the model, ratoon yield was set at 1.0 ton per hectare.

The second experiment was undertaken in order to obtain an indication of the rates of adoption and the potential benefits to farmers to be expected from the introduction of ratoon technology. The initial results, for both small and large farm sizes, showed that ratoon cropping replaced the single crop pattern, with little effect on the area double cropped. As expected, ratoon achieved the highest adoption rates in the shorter rainy seasons and on the sideslope landscape position.

Comparison of the net monetary returns in cases with and without ratoon technology availability indicated that the economic benefits of ratoon were concentrated during the short growing seasons on the smaller farm. The benefits were more evenly distributed among the different rainfall situations on the larger farm, largely due to the presence of binding labor constraints which inhibit double cropping even during intermediate and long growing seasons.

In order to obtain information regarding expected benefits of ratoon, the probabilities of occurrence of each rainfall situation were calculated. The average expected benefit was then determined by multiplying the net benefit under each rainfall situation by the probability of occurrence of that situation and summing the results. The figures obtained represented expected yearly income increases of 6.5% and 8.1% for the small farm and large farm, respectively, under conditions of perfect knowledge regarding rainfall patterns.

In order to account for decisions made under rainfall uncertainty, a probable farmer strategy was imposed on the model.[6/] The model was then rerun for all rainfall and farm size situations, both with and without the availability of ratoon technology. The results indicated increases in expected net returns of 13.3% for the small farm and 12.0% for the large farm.[7/]

The results of the LP analysis indicate that the expected net benefits of ratoon technology are not overly impressive, given the minimum ratoon yield level set and the relative quantities specified of different types of land (sideslope and plain). Therefore, it would be advisable for plant breeders to aim for ratooning varieties with a yield capability somewhat higher than that specified in the model.

An interesting result that the modelling exercise helped bring out is that ratoon technology is biased towards those farmers with poorer quality resources, in this case sloped rather than flat land. Therefore, those farmers with mainly sloped land with little or no potential for multiple rice cropping would benefit relatively more than farmers with plain land suitable for planting two or more consecutive rice crops. Furthermore, it is also biased in favor of those farmers who are relatively risk-averse, as it allows an additional harvest under low risk and low input

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6/ The imposed strategy consisted of including only single or double crop options on plain fields, and single or ratoon crops on the sideslopes.

7/ The expected benefit of ratoon technology was higher for the uncertainty situation than the certainty situation due to the fact that ratoon enters the solution regardless of the rainfall pattern. Therefore, there is always a positive benefit (Table 5.13) whereas in the certainty case (Table 5.12), ratoon is of little or no additional benefit in years with a long rainy season (IL, EL).

(both capital and labor) conditions. Thus, the poorer quality the land, and the more risk averse the farmer, the greater the potential advantages of ratoon technology over those currently available. These aspects would make ratooning quite attractive as a component of a rural development project that attempts to improve the welfare of the relatively poorer (though not necessarily the poorest) members of the rural population.

Limitations of the Study

There are a number of weaknesses in the methodological approach and conceptual framework utilized in this study. These weaknesses, however, are common to nearly all farm system research currently being carried out. The principal drawback is the failure to take into account the effect on small farmers of the national economic policy and the possibilities of improving their productivity through changes in the economic environment. A second limitation pertains to the generalizability of the research results. Farming systems research is fairly site-specific, so that technologies developed for one set of social and ecological conditions may not be appropriate for others.

The third limitation refers to the mainly qualitative nature of the analysis carried out in the study. There are a great many difficulties inherent in obtaining accurate and reliable quantitative data on farming systems, and utilizing it to build simulation models of farm behavior. Furthermore, there is considerable variability among farms, which is difficult to reflect in models requiring the specification of unqiue parameter values. Qualitative information was gathered and used to subjectively reduce the scope of the problem to be examined in a quantitative analysis. Such a methodology, however, produces results that are not statistically verifiable, and hence may not be accepted by researchers who believe that such verification is necessary. Each of the three limitations mentioned is discussed in the following sections.

Alternative strategies for small farm development

The research conducted for this study began under the implicit assumption that the best way to improve productivity and rural welfare is through the development of new agricultural technologies appropriate for small farmers. This focus was to be expected, given the nature and interest of IRRI in particular and the IARCs in general in developing and promoting new technologies.

The difficulties involved in identifying and developing new technologies appropriate to small farm systems are well known. Taking the current socioeconomic environment as given, it seems possible that progress can be made in obtaining improvements in agricultural productivity. There is, however, no guarantee that the benefit from any change would accrue to small farmers or other disadvantaged social classes (e.g. landless laborers). This fact is especially important when the development of new technology is being considered as a key component of rural development efforts designed to enhance the standard of living of the rural poor.

Furthermore, significant concrete results from farm system research are still to be achieved, which in itself illustrates the difficulties inherent in the approach. Detailed farm studies such as the one presented

here are expensive in human and financial resources. This suggests that the search should continue for more effective means for developing the small farm sector.

An alternative strategy for improving small farm productivity would be to modify the socioeconomic context, mainly through public policy changes, in order to relax some of the limitations small farmers currently face. Actions can be taken such as facilitation of credit to small farmers at subsidized interest rates, price supports for small farmer produced products, or technological input subsidies, which could enable small farmers to adopt existing capital intensive technologies. For example, the government policy of a minimum price for rice is not effective for Iloilo due to the lack of storage facilities, which forces government purchasing agents to refrain from buying the farmers' rice during harvest time. Therefore, many farmers are forced to sell to middlemen at sharply reduced prices, thus reducing the incentive and capability of adopting capital-intensive technologies such as fertilizer or other agro-chemicals. The alleviation of the situation through the construction of more storage capacity is potentially an effective way of stimulating increased productivity.

As a consequence of appropriate state policies or action, the range of appropriate technologies would be expanded to include those already developed and available, thus at least partially obviating the need for production system research. Examples of how this type of strategy may become too complex or costly are the special projects that emerged just after the so called "Green Revolution." The observation that few small farmers were adopting the new technologies motivated international aid institutions to initiate "pilot" projects in which special economic and political conditions were created on a small scale in order to permit (induce) farmers to adopt new technology. Some of these projects were moderately successful, though they cannot be applied on a wider scale due to their excessive cost and complexity.

A third alternative is to work simultaneously at both the farm and policy levels. This would imply obtaining some policy changes favorable to small farmers coupled with the development of new technologies appropriate in the new policy environment.[8/] The concept of "integrated rural development" typifies this strategy. The results from many integrated rural development projects, however, indicate that their impact is limited due to the many difficulties encountered in achieving the necessary institutional and economic changes and to the general nonexistence of technology appropriate to small farm conditions.

Generalizability of new technology

One of the questions raised in regard to farming systems research is that new technologies or ideas for new technologies are site-specific and hence may not have much general applicability to other areas. This implies a high-cost research approach. However, many types of environmental conditions are similar enough so that technologies developed for one area would be applicable in other areas.

8/ Examples of such a strategy include Plan Puebla in Mexico and Caqueza in Colombia.

One of the questions raised in regard to farming systems research is that new technologies or ideas for new technologies arise from site-specific research and hence may not be applicable to conditions in other areas. If this were true, the costs of research would be high as efforts would have to be replicated under numerous and variable conditions. Furthermore, a question as to research priorities would arise, assuming that not all potential clients could be served from the limited research resources available.

Fortunately, there is room for optimism with regard to the potential generalizability of farming systems research results. There are many types of environmental conditions typically faced by small farmers in developing countries which are similar enough so that technologies developed in one area would be applicable in others. One example is the ratoon technology conceived for the Iloilo rainfed rice farmers. As stated in Chapter 1 (Table 1.1), there are many areas in South and Southeast Asia which fall into the rainfed lowland rice category. It can be expected that, while these areas may be heterogeneous in certain other environmental aspects, at least the concept of ratooning would apply. In fact, there are areas in India and the Dominican Republic where this is a traditional farmer practice.[9/] Furthermore, Glenn Johnson has suggested (personal communication) that ratoon technology would be applicable in the temperate zones of Japan and Korea, where temperature, rather than water, limits the length of the rice-growing season.

9/ This information was given to me in personal communication from IRRI scholars in plant breeding (M. Mahadevappa from India and Federico Cuevas from the Dominican Republic).

Technologies developed in one specific context may be applicable in others if the original site chosen for study is representative of a larger number of areas. This implies that site selection is a critical part of the farming systems research process, so that some assurance can be given as to the generalizability of research results.

Qualitative vs. quantitative research

One of the issues that arose during the research process was the decision regarding the suitability of qualitative vs. quantitative types of analyses. The Cropping Systems Program had set up a data collection system in an attempt to quantify many types of social and economic as well as agronomic relationships. This included a detailed daily record keeping system to measure such farm family activities as labor allocation to farm enterprises and monetary expenditures and receipts. Unfortunately, much of the potential benefit derivable from the data collection effort was not realized due to the difficulties of managing large amounts of quantitative data, the limited analysis which was done,[10/] and the lack of a good qualitative understanding of the farming system to aid in interpreting the quantitative data.

The most important aspect of the issue is related to problem identification. Farming systems, even just cropping systems, are extremely complex, making it virtually impossible to study every aspect in equal detail. At the initial phase of this study, much sifting of

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10/ Most of the quantitative data was analyzed using arithmetic means, thereby losing information regarding the variability among farm situations.

information was done in order to identify key bottlenecks or constraints. This was done qualitatively rather than quantitatively. For example, instead of making a detailed measurement of farmers' labor and cash allocation over time, farmers were simply asked whether or not lack of labor or cash presented problems during any part of the year. An affirmative response prompted further questioning regarding the times of the year that these problems occurred and their perceived causes. This sort of qualitative research facilitates the understanding of farm-level processes and enables researchers to quickly sort out which factors are problematic and which are not. It also avoids the need for a particularly expensive, onerous and difficult data collection effort.

Once a good qualitative understanding of the conditions farmers face was achieved, the main topic of the research effort was defined. Further qualitative analysis was undertaken to sift through possible technological alternatives until the "best" alternative was found. At that point, quantitative analysis was undertaken to evaluate the technology in greater detail in order to determine its potential benefit to farmers and to provide some guidelines to biological scientists as to its desirable characteristics.

The quantitative analysis undertaken as part of this study played a relatively minor role in the overall analytical effort. It did, however, require significant amounts of data, computer facilities and researcher time, even to address a narrowly defined problem. This points out a cost versus accuracy problem associated with farming systems research. In most situations, neither data nor adequate computation facilities will be readily available, so simpler methods of analysis, both quantitative as well as qualitative, will have to be used. Under such circumstances, researchers will be forced to rely much more heavily on judgment than on measurement. One can foresee problems regarding acceptance of such a strategy by the general research community, which tends to favor quantitative types of analyses. More sophisticated types of quantitative analyses will be limited to the major research institutes when a thorough analysis of the technology is warranted before commiting substantial resources to technological development.

Implications of the Study for Future FSR Work

There are two major conclusions that arose from this study that pertain to future activities in farming systems research. The first is that the generation of new technology appropriate to specific farming conditions should begin with at least a basic understanding of the needs and circumstances of those for whom the technology is designed. The second conclusion is that the integration of information from both biological and social sciences will likely provide the most complete understanding of the relevant system variables. With such an understanding, the chances of developing new technologies which would alleviate farm problems will certainly increase.

This study began about three years after the IRRI Cropping Systems Program had established the Iloilo research site. Large amounts of biological, climatic and socioeconomic data had been collected, and decisions had been made regarding the types of technologies to develop. The socioeconomic data did not provide researchers with a very adequate understanding of Iloilo farm systems, so mainly biological and climatic criteria were used for the selection of technologies to be tested in the area. The major effort was focused on increasing rice cropping intensity with the use of early maturing varieties and dry seeded rice crop establishment techniques. Farmers accepted the early maturing varieties, but rejected dry seeding because of its high yield variability and increased management problems. As mentioned in Chapter 5, dryseeding was a historical technology that had been eventually replaced by transplanting due to the aforementioned problems. Farmers were also quite aware of the differences in landscape position and its effects on multiple cropping potential. Their quite logical reaction was to plant the sloped field first, thus minimizing the probability of yield reduction due to drought stress at the end of the rainy season. One would suspect that much time and effort testing and promoting an inappropriate technology and acquiring topographical concepts of which the farmers were already aware could have been saved if a more thorough analysis of the farm system and the reasoning behind farmers' production decisions had been undertaken at the beginning of the Iloilo project.

The following section provides some guidelines for conducting farmer-focused farming systems research, reflecting the conclusions arrived at in this study.

<u>A suggested methodology for ex-ante technology generation</u>

In order to simultaneously work toward goals of increased food production and rural development, research must be carried out in a number of socioeconomic and agroclimatic environments. To reduce the burden of information collection, and to allow researchers to quickly focus in on the major constraints facing farmers, the farmers themselves should be included in the research process, both as providers of information and as evaluators of new ideas that arise during the course of the research.

A diagram of a "farmer-participant" agricultural research methodology is given in Figure 7.1. The research process begins with substantial interaction between researchers and farm and community systems. Ideally, economists and agronomists should be able to generate socioeconomic and agroecological environmental profiles, which can be combined to provide an initial site description (Cock, 1979).

Concurrent with the farm and community-level effort, a study should be made of the policies governing the relationships between small farmers and the rest of society. This includes examining price, credit and tax policies, general input and product market conditions, and public and private efforts toward the generation and transfer of agricultural technology.

If political conditions are deemed conducive to small farm progress, then farm-level research can begin. If political and economic conditions are not favorable, then it would be worthwhile assessing possibilities for changing them. If substantial changes in the policy environment do not appear feasible, then a search for solutions other than improved technology per se might be appropriate.

Small farms commonly produce a number of products, each of which faces a determined set of economic conditions in terms of prices, markets, etc. Due to the mandates of the IARCs, most farming systems research has been focused on basic food crops that feed the majority of the world's population. It is quite common that national policies related to food crops are

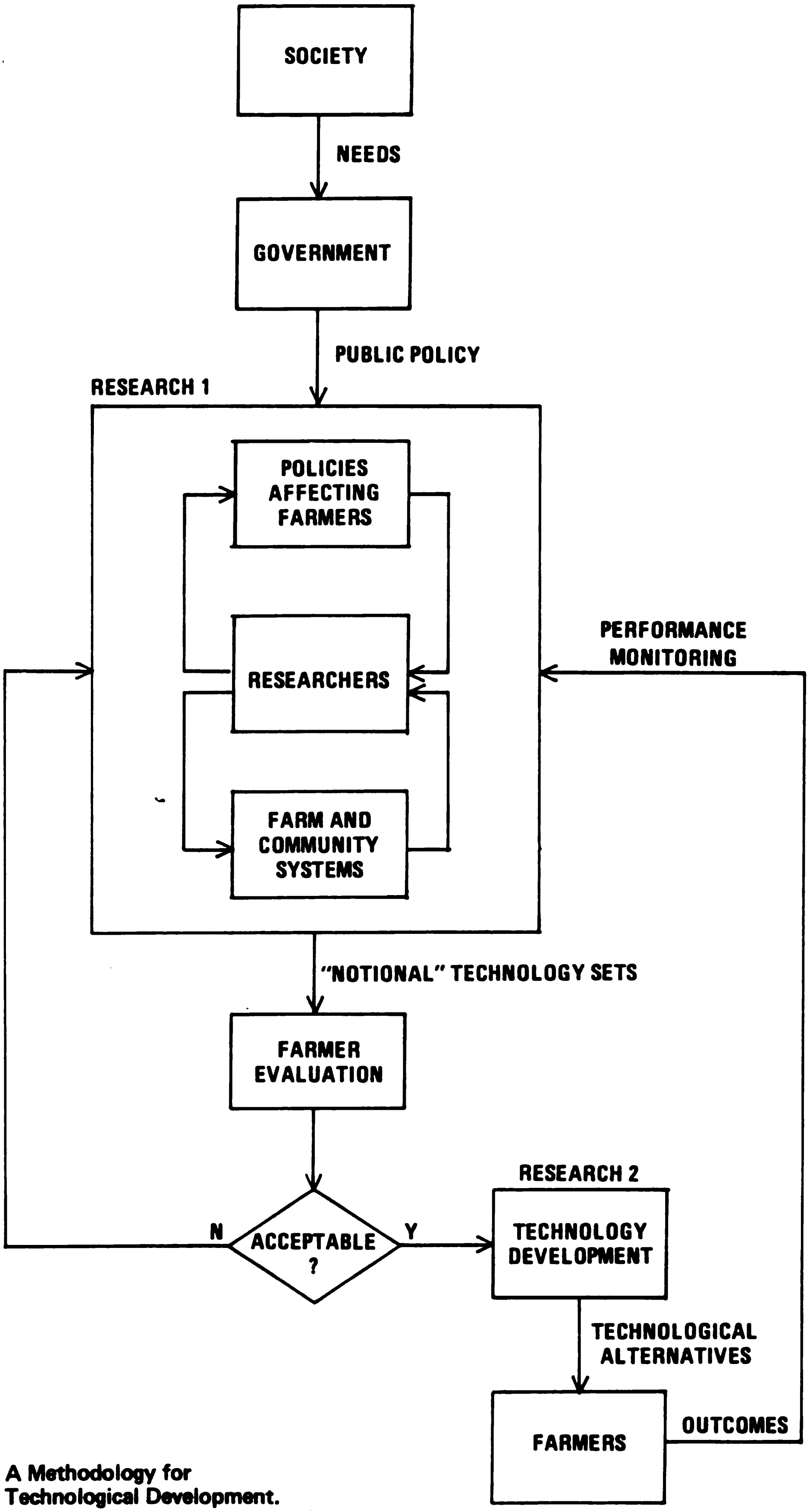

Figure 7.1. A Methodology for Technological Development.

designed to maintain a low-cost market basket. Therefore, the scope is limited for inducing technological changes or for farmers' deriving substantial benefit from technological improvements. In such a situation, it may be wise to redirect the research focus toward products where the economic outlook in terms of potential benefits to farmers is more favorable. Strategies along this line could include introducing non-traditional crop and livestock products, searching for new market opportunities, or organizing small farmers to improve their bargaining power. The strategy selected obviously depends upon the prevailing political and economic relationships. Actions should be taken only after a thorough study determining where the problems really lie.[11/]

If the policy environment is found favorable for certain farm production activities, or if adjustments in the environment are feasible, work can begin on the development of new technologies. At this point, decisions need to be made regarding what technological changes are biologically possible and economically feasible. An attempt should be made to predict the ecological and socioeconomic consequences in order to determine relative desirabilities of technologies, should they be developed (Hertford, 1979).

The next step is farmer evaluation. This does not involve field trials, but rather the collection of thoughts and opinions of a selected number of farmers in the site about the feasibility and viability of hypothetical technological change. Doing this should help reduce the

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11/ In many countries, the "middleman" is usually assumed to be receiving more than a fair share of economic benefit from marketing farm products. As numerous studies have shown, this is not necessarily the case.

required number of technologies that must be dealt with at a developmental stage. In talking with farmers, one is likely to discover new variables which could inhibit the adoption of certain types of technologies. Since farmers are operating with more information than scientists about certain aspects of farming (especially traditional farm and community systems), and less about other aspects, the combination of the two sets of information will likely lead to better decisions with regard to technology development than the use of either set of information alone. Many times, farmers will not be able to give easily understandable reasons why they do what they do. Farming practices evolve over time in response to the environment, and traditional practices sometimes continue even though the environment may have been modified. Farmer actions with no apparent logical base should be considered carefully, and attempts should be made to learn the underlying reasons to see whether those reasons are still valid under current environmental conditions. A sufficient number of farmer opinions should be solicited so that researchers feel sure that the opinions are representative.[12/]

Those technological alternatives rejected by farmers, after being declared possible and feasible by biologists and economists, should be reevaluated in the farm and community system context to find out whether it is worthwhile making adjustments so that the technology can "fit." As researchers pass through the re-evaluation phase, more knowledge is accumulated which may cause reconsideration of technologies already accepted by farmers as feasible.

12/ Wald (1947) presents sequential statistical sampling procedures which would be useful in carrying out this work.

Once "notional" new technologies have been conceived and evaluated, the set of all acceptable technologies coming out of similar processes in different sites should be assembled for ranking. Ranking will help determine the allocation of research resources to the development of the various alternative technologies. Technologies with potential acceptability over a large range of environmental conditions should receive high priority, as should those which utilize farmers' current resource levels to their greatest extent without major system modifications. Specific ranking criteria include those discussed in Chapter 5.

With the basic groundwork accomplished, scientists can begin to find ways to achieve acceptable performance of the new technologies on the experiment station, if biologically feasible. Economists can collaborate by specifying limits of acceptable performance and by using models to synthetically test their stability under different environmental conditions.

New technologies can be released as they are developed and eventually become part of the farmers' "opportunity set." Continued research will need to be done to refine the system. This will be done by searching for productivity increments through better crop management practices or multiple cropping. Farm-level outcomes may bring out previously undiscovered problems, which may require the development of other new technologies. Performance monitoring by researchers completes the feedback "loop" and makes the process dynamic.

Over time, farming systems and their environments will change, so all technologies are interim in nature. Capital-using technologies may replace capital-saving ones if the interim technologies can produce enough gain to allow capital accumulation to take place.

A number of technologies can be developed and tested in specific environmental situations. They may, however, be appropriate for use in other areas for reasons not yet understood by researchers. Though farming systems exist in a large number of environments, the number of technologies in some way suited to the different environments may be small. Technologies designed at research stations can be thought of as "seed" material. That is, the basic ideas and materials are developed and presented to farmers for adaptation before adoption. No single technological package will be wholly adopted by farmers, due to the variety of environ- mental conditions and limitations in different farming areas. Therefore, as certain parts of technological packages are accepted while others changed or rejected, farmers actually invent their own new technologies. There is no one appropriate technology for any area, so farmers should be provided with a number of technologies from which they can choose. A larger objective of research, then, is not developing one or more specific technologies, it is that of expanding the farmer's opportunity set. The farmers themselves are the ultimate judges of which technology, or set of technologies, is most appropriate.

A quote from Morss et al. (1976) in an evaluation of the Plan Puebla project in Mexico best sums up the lesson learned by the author during this research experience:

> In the last analysis, the crux of the rural development dilemma lies less with persuading small farmers to adopt new behavior recommended by outsiders than it does with persuading outsiders to change their behavior and attitudes toward small farmers. And chief among the changes required of outsiders is the realization of their own vulnerability; that they do not have all the answers, that they cannot monopolize the process of rural development; that they cannot, in brief, help small farmers without the latter's assistance.

APPENDICES

APPENDIX A

APPENDIX A

AGROCLIMATIC CONDITIONS AND THEIR EFFECTS ON CROP PERFORMANCE IN ILOILO

For the rainfed lowland area of Iloilo, the following factors have been observed to influence the performance of tested cropping patterns; rainfall, landscape position, soil texture, water table depth and water management class (level of irrigation) (Magbanua, et al, 1978; Moorman and van Breeman, 1978).

Landscape Classification

The results of the first year of cropping pattern trials prompted cropping systems researchers to develop a paddy field classification scheme based on factors which modify local hydrological conditions (Moorman, et al, 1976; Raymundo, 1977). The difference in the cropping potentials among paddy fields is largely related to the availability of water and, to a lesser degree, moisture demanded by a particular crop. In rice-growing areas, a large portion of water (from rainfall or irrigation) is retained on the surface, and its depth can usually be manipulated by controlling runoff (IRRI, 1976).

The paddy field position classification reflects the capability of land to be drained or to accumulate water as determined by the geomorphic landscape, soil texture, and relative paddy field location within the landscape.

The landscape of the Iloilo test site has been divided into five geomorphic classifications; knolls (or summits), plateaus, sideslopes, plains and waterways (or bottom lands) (Figure A.1).

Knolls. Knolls are small hilly areas which are easily drained and cannot accumulate water. They are frequently comprised of loamy soils and have a low production potential for rice. They are not normally bunded,[1/] and in most years only upland crops (including upland rice) can be planted in these areas.

High plateaus. High plateaus are generally level areas with a water table that recedes rapidly with the onset of the dry season. The paddy fields are generally large, square and enclosed with bunds. Due to the minimal vertical drop between fields, plateau areas are difficult to drain. Therefore, surges in the monsoon (heavy rains) tend to waterlog them. Waterlogging damages upland crops early in the rainy season, and delays the planting of upland crops after rice late in the rainy season.

During the dry season, winds can substantially increase evapotranspiration rates of exposed crops. Therefore low-stature crops, or those of creeping habit, would be favored.

Sideslopes. These areas usually connect knolls and plateaus, or plateaus and plains, and are terraced and bunded. Paddy fields on sideslopes are narrow with their longer sides perpendicular to the slope, and with greater vertical drop between them than either plateaus or plains. The fields can accumulate water and be drained only during the

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1/ Bunds are dykes which surround rice fields enabling water retention.

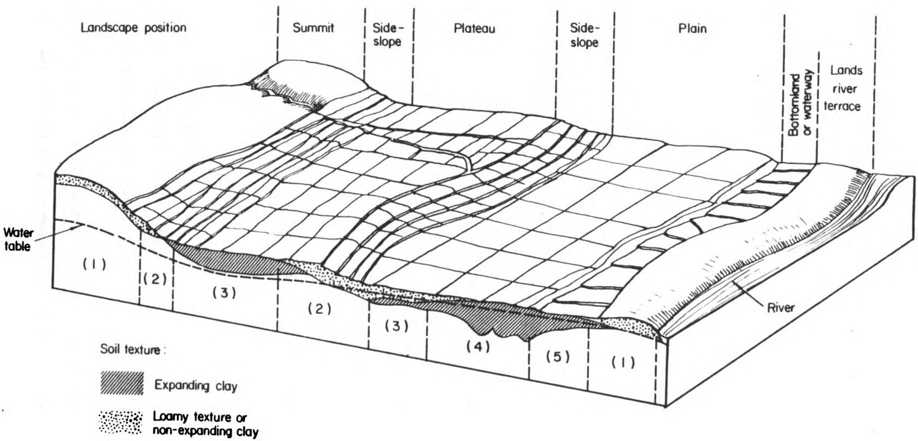

Figure A.1. A schematic presentation of geomorphic conditions at the Iloilo site. (Source: Raymundo, 1976) rainy season. Because of surface drainage, upper sideslopes are appropriate for early upland crops planted at the beginning of the rainy season, followed by puddled rice. Lower sideslopes are generally protected from winds, so there is less need for low-profile upland crops. Since surface drainage is good, upland crops can be planted earlier (upon termination of heavy rains) than those planted on more level areas.

Plains. The low plains include flood plains which have a high water table and which tend to have heavier soils than the plateaus. Like the plateau areas, the paddy fields are generally wide and nearly square, with a small vertical drop between them, making surface drainage difficult. The low plains are usually well protected, so wind does not become a problem.

Due to the flat surface and relatively high water retention capacity, of plain soils, rice can be double cropped successfully during extended rainy seasons. Upland crops following rice can include many of the drought-sensitive as well as drought-tolerant cultivars.

Waterways. Waterways are the lowest areas in the topographical sequence. Flooding during the rainy season limits the use of short-statured rice varieties; the utilization of early maturing intermediate-statured varieties frequently allows the planting of two or more rice crops during a wet season. Upland crops can be planted after rice in years with a relatively short rainy season.

In general, within a given geomorphic landscape position, the cropping potential for wet puddled rice increases in sequential steps from the top of the slope (summit) to the bottom (waterway). Conversely, the conditions for dryland culture improve proceeding up the slope from the conditions for dryland culture improve proceeding up the slope from the bottom.[2/] Therefore, higher paddy fields are most likely to be planted to dryland crops at least part of the year while the physical potential for multiple rice cropping being greater on lower fields with a greater (and longer) water supply.

Hydrological Effects on Cropping Potential

The relationship between landscape position and cropping potential can be atributed to differences in the hydrology of the paddy fields in different locations. Flooding potential and ease of surface drainage are important factors. Both of these factors are affected mainly by soil type, water table depth, gravitational forces and water source.

Soil types. Three general soil types are common in the Iloilo area:

a) Clay soils - Fine textured soils, comprised of clay and heavy clays.

b) Loamy soils - Medium textured soils, ranging from sandy loam to silty loam and clay loam.

c) Sandy soils - Coarse textured soils, normally classified as loamy sand.

2/ Modification of this and the previous statement is in order. The statements are generally true during the rainy season, though flooding may occur in the lowlands which would reduce their rice production potential compared to some higher positions. During the drier months of the year, the lower positions become relatively more favorable for dryland crops, as their relatively high moisture retention capacity help to lengthen the effective growing season.

Water table depth. The depth at which water flows beneath the surface of a paddy field influences the capacity of that field to retain or lose soil moisture. As water is added to a field (either via rainfall or irrigation), water penetrates the subsoil layers at different rates due to different subsoil textures. When seepage water reaches the ground water level, it begins to flow laterally. If, however, the rate of seepage is greater than the rate of lateral flow, water will begin to build up through the subsoil layers until saturation or surface flooding occurs.

Water sources. At the Iloilo site, four water management classes were distinguished (Table A.1).[3/] The classification is based on the availability of irrigation water, which in turn is largely related to the proximity of paddy fields to irrigation canals. The opportunity for multiple rice cropping is enhanced on fields with access to ample supplies of irrigation water. Rice productivity is greater in higher water management classes, especially for second and third rice crops which would be subjected to substantial drought stress if grown under strictly rainfed conditions (Table A.2).

A review of the preceeding discussion of agroclimatic conditions and their effect on cropping potential leads to a modification of concepts concerning wet season and dry season.

Previously, wet and dry seasons were defined strictly in terms of average rainfall pattern. For Iloilo, the wet season was specified as a consecutive time period during which rainfall was greater than or equal

3/ These categories differ slightly from those presented in Table 1.4 in that upland is not included and the partially irrigated class is divided into two sub-classes.

Table A.1. Description of the different water source classes occurring in Iloilo test site.

Class	Description
I	Strictly rainfed. No supplemental irrigation. Depends entirely on rainfall for water accumulation.
II	Partially irrigated. With supplemental irrigation at least one month after the end of the rainy season.
III	Partially irrigated. With supplemental irrigation 1 to 2 months after the end of the rainy season.
IV	Fully irrigated. Has available water 11 or more months of the year.

Table A.2. Difference in average yields of rice crops in CSP experimental trials by water source class (kg/ha). Iloilo 1976-77 crop year.

Rice crop	Water Source Class			
	I	II	III	IV
First	4819 (48)	5532 (27)	4887 (22)	5559 (10)
Second	2003 (41)[a]	3476 (20)	4603 (21)[c]	4193 (11)
Third	0[b]	3375 (1)	3464 (4)	3543 (10)

[a]/Excluding 8 failures.

[b]/Failed.

[c]/Excluding 1 failure

() = number of trials.

to 200 mm per month (Figure 2.1). The dry season was similarly defined as that period during which rainfall was less than 100 mm per month. The other months were called "intermediate" seasons.

Concepts of "effective" wet and dry seasons were developed using the knowledge gained regarding the hydrological effects of various lanscape positions on moisture status.

Topographical Effects on Crop Yields in Iloilo

Rice

The importance of landscape position of paddy fields as it affects rice crop yields has been studied through cropping pattern experiments conducted by the CSP in Iloilo since 1976. In order to validate and verify previous discussion regarding the effects of rainfall and landscape position on crop performance, some results of CSP experiments are presented here.

Tables A.3 and A.4 contain average yields of rice crops grown as part of the cropping pattern trials in the Iloilo area. Experiments are conducted on both rainfed and partially irrigated land. The figures presented represent strictly rainfed land for Crop Years 1976-78, while a small number of partially irrigated plots were included with the rainfed plots in 1978-79.[4/] Table A.3 contains average yield data for modern variety[5/] rice crops established at the beginning of the wet season,[6/]

4/ Individual plot data was not available to author at time of writing.

5/ High yielding (HYV) and/or early maturing (EMV) varieties. Among those tested were IR28, IR30, IR36 and IR1561.

6/ Also known as "first" rice crop.

Table A.3. Average yields (t/ha) of rice crops (modern varieties) established at the beginning of a wet season, by landscape position. CSP cropping pattern trials. Iloilo Crop Years 1976-79.[a/]

Crop year	Landscape position			
	Bottomland	Plain	Plateau	Sideslope
1976-77[b/]	5.3(5)[c/]		5.3 (32)	5.0 (15)
1977-78[b/]	5.9 (8)	5.1(25)	5.2 (28)	4.9 (30)
1978-79[d/]	5.5 (9)	5.1(20)	4.8 (25)	4.0 (13)
3-year weighted average	5.6	5.1	5.1	4.7

Table A.4. Average yields (t/ha) of rice crops (modern varieties) following a previously established and harvested rice crop (in same season) on rainfed land, by landscape position. CSP cropping pattern trials. Iloilo Crop Years 1976-79.[a/]

Crop year	Landscape position			
	Bottomland	Plain	Plateau	Sideslope
1976-77[b/]		3.4(4)[c/]	2.3(30)[e/]	1.7(10)[f/]
1977-78[b/]	2.6(8)[g/]	1.4(16)[h/]	0(1)[g/]	1.0(2)[g/]
1978-79[d/]	3.8(7)	3.1(11)	3.9(11)	4.0(3)
3-year weighted average	3.2	2.3	2.6	2.1

a/ All plots were fertilized with 90 kg N/ha (3 applications) plus other fertilizers as needed; high levels of chemicals were applied to control insects, and weed control was variable.
b/ Computed by author.
c/ Bottomland and plain were not distinguished.
d/ Source: Component Technology Research Staff (1979).
e/ Includes 5 failures.
f/ Includes 3 failures.
g/ Includes 1 failure.
h/ Includes 7 failures.
( ) = Number of observations.

by landscape position. In the 1976-77 Iloilo cropping season, plots in bottomland and plain positions were not considered separately. Average first crop rice yields indicate landscape position effects. The 1977-78 figures showed a possible distinction between bottomland and the other landscape positions taken together. In 1978-79, plots on sideslopes averaged 1.5 t/ha less than those on bottomland. A relatively small difference was detected among bottomland, plain and plateau.

A 3-year average, with each year's average weighted by the number of observarions in that year, was calculated for each landscape position for the first rice crop.[7/] The figures tend to distinguish 3 categories, though the yield differences are not great; (1) bottomland, (2) plain-plateau, and (3) sideslope.

Average yields of modern variety rice crops planted after a previous rice crop has been planted and harvested (in the same season)[8/] are presented in Table A.4 for Crop Years 1976-79. Since second rice crops are usually established late in the season (late September - early November), they are subject to greater probabilities of significant yield reduction due to drought stress. Therefore, lower average yields would be expected for second rice crops than for crops planted at the beginning of the wet season.

The effects of varying landscape position are more apparent for second rice crops than for first crops. In 1976-77, average yields on sideslopes were half those recorded for bottomland-plain positions. Average yield on

7/ The 1976-77 figure for bottomland-plain was used for calculating both separated weighted averages for bottomland and plain.

8/ Also called "second" rice crop.

plateau differed by 1.1 tons/ha and 0.6 tons/ha from bottomland-plain and sideslope, respectively. In 1977-78, average second rice crop yields on bottomland were nearly double those recorded on the plain fields. Second rice crops tested in 1978-79 produced similar average yields on all landscape positions. A 3-year weighted average indicated a noticeable difference between bottomland and the other landscape positions.

The information presented so far weakly supports theoretical notions regarding the effects of landscape position on rice crop performance. However, averaging tends to cancel out intra-year variations, even within the same landscape position. Table A.5 presents information regarding yield variation within landscape classes for 1977-78. For the first rice crop, modal yields were in the 6-8 tons/hectare range for bottomland, in the 4-6 tons/hectare range for plain and plateau, and nearly evenly distributed in the 2-4 and 4-6 tons/hectare ranges for rice planted on sideslopes. For the second rice crops, the modal yield range was 2-4 tons/hectare for bottomland and 0-2 tons/hectare for plain. Sample sizes for plateau and sideslope were quite small (1 and 2 respectively) indicating that soil moisture conditions in those positions were deemed inappropriate for planting a second rice crop.

The examination of yield distributions strengthens the evidence regarding landscape position effects. The same general yield relationships hold from year to year but the absolute yield values for the second rice crop may vary according to changes in rainfall patterns. The relative

Table A.5. Yield variations of 2 rice crops on CSP cropping pattern test plots under similar management conditions,[a] by landscape position. Iloilo Crop Year 1977-78.[b]

Yield Range (t/ha)	Landscape position			
	Bottomland	Plain	Plateau	Sideslope
First crop		No. of plots		
0-2	-	-	-	-
2-4	1	5	5	10
4-6	2	16	16	13
6-8	5	4	7	6
8+	-	-	-	1
Second crop				
0-2	2	10	1	1
2-4	5	5	-	1
4-6	1	1	-	-

Table A.6 Yield variations of 2 rice crops on CSP cropping pattern test plots under similar management conditions,[a] by landscape position. Iloilo Crop Year 1976-77[b]

Yield Range (t/ha)	Landscape position		
	Bottomland-Plain	Plateau	Sideslope
First Crop		No. of plots	
0-2	-	2	-
2-4	-	3	4
4-6	4	19	9
6-8	1	7	2
8+	-	1	-
Second Crop			
0-2	1	12	4
2-4	2	13	6
4-6	1	5	-

a/ See footnote a/, Tables A.3 and A.4.
b/ Compiled by author.

yield distributions for 1976-77 (Table A.6) are similar to those for 1977-78, though modal yields vary greatly for the second rice crop. The reasons for this variation become evident upon examination of the monthly rainfall patterns at the Iloilo site for 1976-77 and 1977-78 (Figure A.2).

Second rice crops are normally planted between late September and early to mid-November. Two major factors affected the success of second rice crops in both crop years; (a) the time of planting of the first rice crop, and (2) the rainfall pattern after the second rice crop is planted. The site received over 500 mm of rain in May 1976, which enabled establishment of first rice crops in late May - early June. In 1977, on the other hand, May was a dry month, so it was not until mid to late June that rice crops began to be planted.

Since first rice crops were established about one month earlier in 1976 than in 1977, farmers were in a position to plant the second rice crops earlier as well. Most crops were established in the mid-September to mid-October period, and though rainfall was a bit short in October (120 mm), it picked up in November (170 mm) providing sufficient moisture to maintain reasonable second crop yields. In 1977, however, the situation was quite different. The first paddy fields were established a month later than in 1976, causing late planting of the second crop (mid-October to mid-November). Unfortunately, November 1977 was a dry month (70 mm rainfall) and the months that followed were even drier. Thus, the combination of a late onset of rainfall in 1977, plus an early termination, caused second crop yields to be substantially lower than those obtained in 1976.

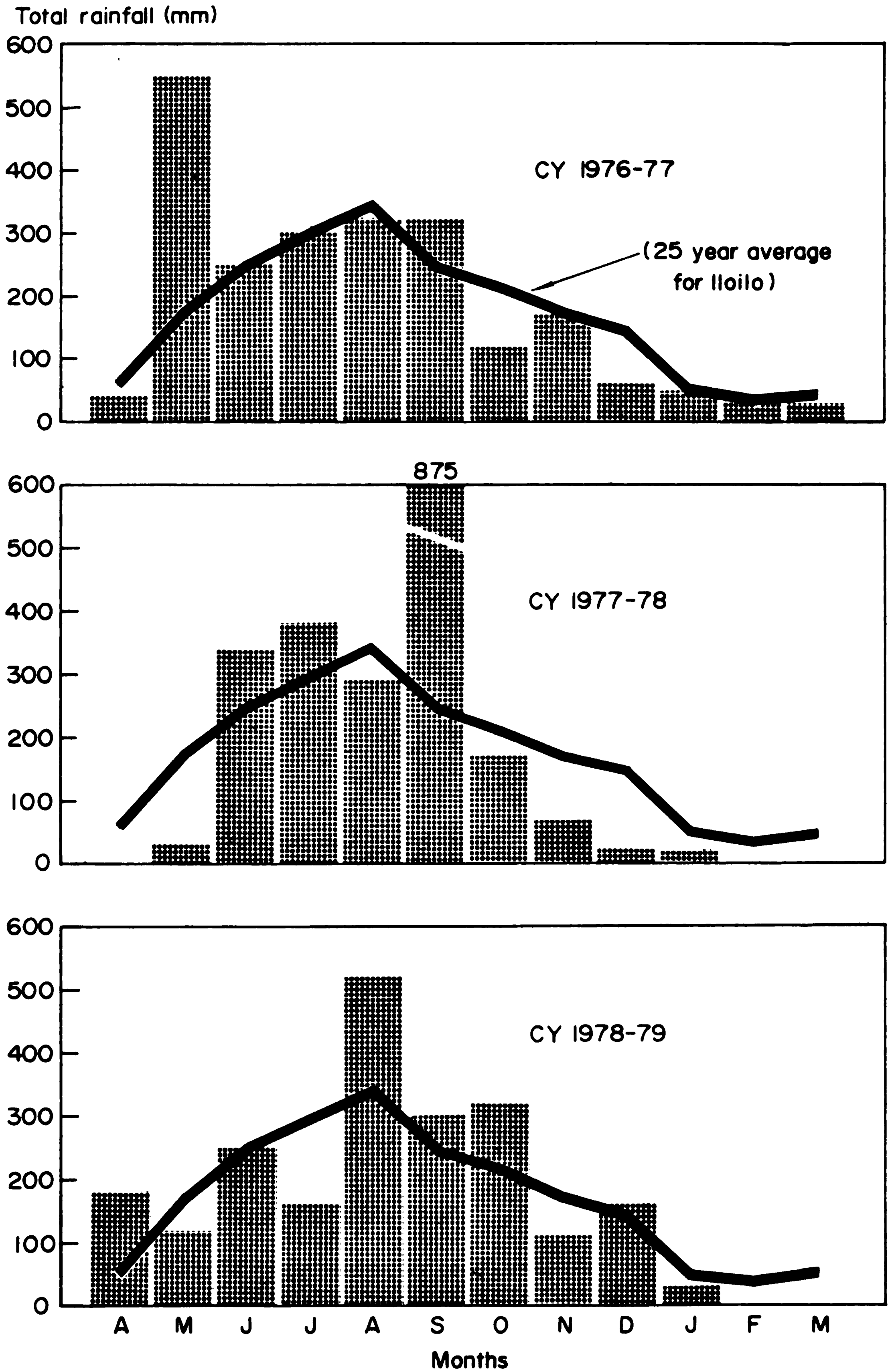

Figure A.2. Monthly rainfall patterns, Iloilo Outreach Site, 1976-1979.

The monthly rainfall pattern for 1978-79 is presented in Figure A.2. The onset of the wet season was even earlier than in 1976, though rainfall did not surpass 200 mm until June. The second rice crop season conditions were even more favorable than in 1976, with an unusually wet October and rainfall above 100 mm through December. Thus, the high average second crop yields for 1978-79 presented in Table A.4 are quite consistent with expectations.

Upland crops

The effects of landscape position on the performance of upland crops are less dramatic than on rice. Upland crops can be planted soon after heavy rains cease on upper landscape positions (sideslope, high plateau) with light to medium soils. Crops in these fields are less likely to suffer flood damage effects should a surge in rainfall occur after planting.

Fields with heavier soils in the lower landscape positions cannot be planted until late in the wet season when heavy rains have subsided and flooding has ceased. Because of favorable moisture retention characteristics, upland crops can produce reasonably well, though moist microclimates are attractive to insect pests and diseases. Due to the lack of flooding tolerance, serious yield reductions may occur should heavy rains surge at the end of the wet season.

Table A.7 presents yield performance figures for 4 upland crops planted after a single rice crop in Iloilo during 1977-78, by landscape position. Most upland crops were successfully established on the sideslope and plateau positions, mainly because upland crops did not have

Table A.7 Performance of upland crops planted after one rice crop by landscape position. Iloilo 1977-78 crop year.

Crop	Landscape position	No. of fields	Yield (t/ha)
Mungbeans	Sideslope	7	0.7 (2)
	Plateau	7	0.6 (2)
	Plain	2	0.9 (0)
Cowpeas	Sideslope	7	1.1 (2)
	Plateau	7	0.2 (4)
	Plain	3	0.6 (1)
Sorghum	Sideslope	5	2.7 (0)
	Plateau	4	2.2 (1)
	Plain	1	2.8 (0)
Peanuts	Sideslope	2	0.5 (1)
	Plateau	2	0.9 (1)
	Plain	-	-

( ) number of failures. The failures were included as zero yield in the computation of means.

Source: Magbanua, et al (1978).

to compete with a second rice crop in these positions. Only for cowpea did yields vary significantly with changes in landscape position.

The empirical evidence presented here generally supports theoretical notions developed earlier regarding the effects of rainfall and landscape position on rice crop performance. The following generalities can be asserted:

1. For the first rice crop, yield effects of landscape position are difficult to detect due to the fact that water is normally sufficient to prevent yield loss from drought stress. Differences in average yields and yield distribution of plain and plateau are slight, suggesting the feasibility of combining plain and plateau into a single landscape classification.
2. The yield effects of landscape position on second rice crops are very important, especially in years with short wet seasons. Second rice crops on all positions except bottomland are likely to fair poorly during years when October to December rainfall levels fall below 100 mm per month.

Due to undertainties regarding rainfall and landscape effects, a cropping pattern containing 2 consecutive rice crops is unlikely to be stable for rainfed farmers in the Iloilo area.

APPENDIX B

APPENDIX B

BIOLOGICAL EFFECTS ON CROP YIELDS IN ILOILO

Insects and Diseases

The overall objective of CSP crop protection research is to derive a package of recommendations for pest control that fits the complexity of multiple cropping systems, that is in harmony with management recommendations stemming from research in other disciplines, and that is feasible for farmers with limited financial resources (Inter-disciplinary Research Team, 1978).

Despite the fact that chemical purchase and use may be beyond the financial capability of farmers, pesticides are a mainstay of the pest management program (Interdisciplinary Research Team, 1978). Pest resistant crop varieties are most attractive because no inputs (other than seed) are required for the control of certain insects. However, very few resistant varieties have been recommended for crops other than rice.

Rice

The major insect pests affecting the performance of rice crops in Iloilo are listed in Table B.1. No insect pest significantly affects the performance of the rice crop planted at the beginning of the rainy season (first rice crop). If a second crop is planted, certain insects begin to create problems. White or striped rice stemborers, green-horned caterpillars and rice bugs can cause measurable yield losses. The rice caseworm, however, can cause significantly high yield losses. Yellow and white stemborer populations can cause yield loss should a third rice crop be planted (usually only in waterways and irrigated lands).

Table B.1 Insect pests present in lowland rainfed rice at the Iloilo CSP Outreach site. a/

English Name	Local name	1st crop	2nd crop	3rd crop
Yellow rice stemborer	Tamasok	-	*	**
White rice stemborer	Tamasok	-	**	**
Striped rice stemborer	Tamasok	-	**	*
Dark-headed rice stemborer	Tamasok	-	*	*
Pink stemborer	Tamasok	-	*	*
Rice caseworm	Salabay	-	***	-
Rice green-horned caterpillar	Ulod	-	**	-
Hairy caterpillar	Ulod	-	*	-
Rice leaf folder	Ulod	-	*	-
Rice bug	Tiangaw	-	**	-

- insect not present.
* occasionally a pest.
** pest causing marginal yield loss.
*** key pest causing high yield loss.
a/ Derived from: Interdisciplinary Research Team (1978); Table 12.

First rice crops escape pest buildups because they are usually planted with the onset of rains after a 4-5 month host-free period. No rice pests are able to hibernate during the dry fallow period in order to reappear at the beginning of the rainy season. By October, rice pest populations have built up on the first rice crop, or alternate weed hosts, in order to present problems for the newly planted second crop. Only stemborers were found to reduce yields in a third rice crop, though the build-up of these and other types of pests may occur if rice is grown continuously (Kenmore, 1979).

No major disease problems have been encountered with either local or modern rice varieties. However, the CSP recommends continued use of tungro-resistant varieties (transmitted by green leafhopper). The disease occurs sporadically throughout the humid tropics of Asia and can cause severe damage and heavy yield losses (Chandler, 1979).

Upland Crops

Pest incidence and subsequent yield losses are much more prevalent for dryland crops than for rice. On high, well-drained fields, green corn can be grown before rice in years of a gradual onset of the rainy season. The Asian corn borer has caused significant losses, reducing yields by as much as 33% in 1976. The use of insecticides to control pests on green corn has not been recommended due to farmers hesitance to use chemicals on crops they continuously harvest for livestock feed. Also, recommended insecticides have not proven effective in Iloilo. No corn variety has been found with a higher level of resistance to corn borers than the two commonly grown local varieties, Singapore Orange and Pilit (glutinous corn).

Mungbeans and cowpeas commonly follow rice crops in Iloilo when no second or third rice crop is possible. Yields are generally low (less than 1 t/ha), mainly due to the common occurrence of drought stress. There is some evidence of tillage effects on an insect predator of cowpea, the beaufly. Results indicate that the incidence of larvae and pupae is less in fields with zero tillage than in fully tilled fields (Interdisciplinary Research Team, 1978).

Mungbeans are usually highly infested with powdery mildew when planted after rice. The incidence of disease in cowpea has been low, possibly due to the low number of disease-carrying insects.

Weeds

Weeds compete with rice and other crops for the essential elements for plant growth, light, water and nutrients. In general, the longer weeds grow in association with a crop, the greater the reduction in yield. The seriousness of weed problems depends upon the quantity of weeds present and their relative abilities to compete with the planted crop.

Rice

Weeds thrive under dry soil conditions, occuring in large numbers with a greater species diversity than in rice which is grown in flooded paddy fields. They emerge before or simultaneously with rice, and hence are more competitive than when pre-germinated rice seeds are broadcast, or seedlings are transplanted, onto previously puddled, flooded soil.

The principal methods of weed control in Iloilo are thorough land preparation, high density seeding, handweeding, and application of herbicides.

The role of land preparation and its importance as a weed control technique is not often discussed. Plowing uproots weeds, leaving seeds to germinate. Farmers in Iloilo often wait for a week or so after plowing inorder to let weed seeds germinate, and then harrow several times to uproot the seedlings.

Higher rates of seeding per hectare should allow rice to be more competitive with weeds, and perhaps reduce the time needed for handweeding. Seeding rate experiments were carried out in Iloilo in 1976. The results (Table B.2) showed no significant difference in yield and weed weight among plots treated with butachlor and untreated plots. This apparent lack of effect may indicate that besides competing with weeds, rice is successful at competing with itself at high seeding rates.

The effects of three herbicides applied to test plots of first-crop wet-seeded rice are presented in Table B.3. There were significant differences encountered in weed weights, though no statistical difference was detectable in yields among treatments.

Table B.2. Effect of seeding rates on weed weight and grain yield of wet seeded first rice crops. Iloilo 1976-79 Crop Years.

Seeding rate Kg/ha	Weed weight (t/ha)	Yield (t/ha)a/
80	1.7	4.3
120	1.2	4.3
160	0.9	4.4
200	0.6	4.5

Source: Interdisciplinary Research Team (1978)

Table B.3. Effect of herbicide on yield of wet-seeded rice. Iloilo 1976.

Treatment	Herbicide rate kg/ha	Weed weight (g/sq m) a/	Yield (t/ha)a/
Thiobencarb/2,4-D	0.25/0.25	104.4 d	4.8a
Piperophos/dimethametryn	0.4/0.1	124.4 c	4.3a
Butachlor	1.0	149.6 b	4.2a
Untreated	-	333.2a	3.3a

a/ In a column, means followed by the same letter are not significantly different at 5% level.

Source: Interdisciplinary Research Team (1978).

Upland crops

A number of experiments in Iloilo have been carried out in order to investigate the effects of intercropping on weed growth. Again, the basic notion is that increased competition against weeds will occur with a greater crop density or changes in crop canopy characteristics. For example, highly significant differences were found in yields and weed weights among weed treatments in plots with corn growing in association with cowpea (Table B.4).

Table B.4. Yield of corn + cowpeas as affected by frequency of weeding. Iloilo 1976.

Treatment	Weed weight (g/sq m)a/	Crop Yield	
		Corn (t/ha)a/	Cowpeas (g/ha)a/
Two hand weedings (1 and 4WAE) b/	3.2 c	1.4a	0.35a
One hand weeding (3 WAE)	13.2 b	1.3a	0.32ab
No weeding	138.0a	0.6 b	0.24 b

a/ In a column, means followed by the same letter are not significantly different at the 5% level (DMRT).

b/ WAE - weeks after emergence.

Source: Interdisciplinary Research Team (1978).

APPENDIX C

APPENDIX C

SOCIOECONOMIC CHARACTERISTICS OF ILOILO FARMS[1/]

The purpose of this appendix is to present some general information regarding the Iloilo socioeconomic environment. The discussion is focused on sources and uses of labor and cash, and types of access to land.

General Characteristics of the CSP Research Site

A total of nine barangays (villages) compose the IRRI Cropping Systems Program Outreach Site in Iloilo Province (see Figure 1.1). The research site was originally chosen for its representativeness in terms of such agroclimatic characteristics as soils, water management (rainfed lowland), weather and geomorphic land characteristics. Six of the barangays are located in the municipality of Tigbauan, with the remaining three located in Oton. Tigbauan and Oton are located 22 and 11 kilometers respectively from the provincial capital, Iloilo City, and are accessible by connecting unpaved roads during most of the year. The site has a perimeter of 39 kilometers.

As indicated by a 1975 baseline survey, the total site population was 7,093, with an average barangay population of 975. The population per barangay ranged from 400 to 1,300 persons. There were a total of 1,286 households, 67 percent of which were headed by farmers. Other common

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1/ The information presented here was obtained from studies conducted on the daily farm records kept by 45 farmers between 1976 and 1979. The principal references used were Roxas and Genesila (1977) and Genesila, Servano, and Price (1979).

professions of the heads of households were factory worker, driver, military, and in-service government employees. The average family size was 6.1 persons, with 2.8 males and 3.3 females per family. The average number of economically active members per family was 3.9. The average level of formal education attained by family members was 5.5 years.

Land Access and Use

The average size of an Iloilo farm was approximately 1.5 hectares. Only a few of the farmers owned all of their land, with the most common land tenure arrangement being share tenancy. On average, farmers owned about two-thirds of the land they farm and share rent one-third. On the share-cropped area, the landlord and tenant receive equal shares of the crop produce after equally dividing crop cash and harvest expenses.

The quality of land is a major factor in determining land use, both in terms of types of crops as well as intensity (number of crops per year). In 1975, less than 10 percent of the total cultivated area at the test site was under irrigation. A number of irrigation projects were begun in the early 1970s, causing the percentage of cropland under irrigation to gradually increase to 34 percent in 1979 (Table 1.3).[2/] In general, there was a significant increase in cropping intensity in the whole area, with a double rice crop pattern becoming predominant. This was due mainly to the following reasons:

1. The use of an early maturing variety.
2. The advent of irrigation facilities in some areas.

2/ A discussion of the relationships of land quality and use of land in terms of cropping pattern variation is discussed in Chapter 1.

3. A reduction in the time between harvest and subsequent planting of a second crop, due mainly to the increasing utilization of hand tractors and mechanical threshers.

Labor Sources and Uses

Sources of labor

Iloilo farmers typically utilize labor from four major sources: the farm operator, family members, hired laborers from the community labor pool, and occasionally on an exchange basis.

Operator. The major operation in which the farm-operator is engaged is land preparation, which includes plowing, harrowing and leveling with a carabao or hand tractor. This usually accounts for about one-half of all labor use during the planting season (May-June). The operator is also responsible for other jobs such as fertilizing, spraying, weeding and general supervision of farm productive activities. It is also quite common for the operators of smaller farms to dedicate some time to off-farm work during slack periods. These activities include mainly land preparation on a cash wage basis, and harvesting on a crop-share basis.

Family members. The role of family members as providers of labor services varies according to the age and sex composition of the family, the number of economically active members, and the size of the farm. Family labor is used mainly in crop maintenance (particularly hand weeding) and harvest. It is also common for younger family members to dedicate significant amounts of time to caring for small ruminants.

Hired labor. Hired labor normally contributes more than 50 percent of total labor use, concentrated in transplanting and harvesting activities. These activities are the most labor intensive and are relatively critical in terms of timing. Thus, family and operator labor is usually insufficient. Since crop activities are staggered throughout the year, hired labor use is spread over the cropping season fairly evenly, though on a single farm it may be very concentrated in a short period of time. The community labor pool is made up principally of the small farmers themselves and their families. Labor migration from other areas is rare, as is the presence in the Iloilo community of strictly landless workers.

Exchange labor. The exchange of labor services among neighbors is a traditional practice that has gradually been replaced by monetary relationships (hired labor). Exchange labor in Iloilo is no longer common, and constitutes only about three percent of total labor use (mainly in land preparation).

Summarizing labor use by source, it was found that on average the farmer-operator contributes 25 percent of the total labor, 14 percent is provided by family members, 58 percent is hired, and the rest is exchanged.

Labor use by operation

There are three major activities associated with rice production: land preparation and planting, crop maintenance, and harvest and post-harvest operations. Due to the adoption of non-photosensitive rice varieties, all of the major activities can take place at any time during the year. However, especially in the rainfed areas, certain activities tend to be concentrated in specific seasons. For example, labor use for land preparation and planting (wet seeding) is greatest during April to June, for transplanting in July and August, and for harvesting in September and December. Crop maintenance activities are less critical, and thus are more evenly distributed throughout the crop season. The exact distribution of rice production activities is heavily dependent on the rainfall pattern occurring during a season.[3/]

The labor requirements for rice production by activity vary somewhat according to the method of planting. The two most common planting methods in Iloilo are wet seeding (WSR) and transplanting (TPR). In WSR, labor use is distributed mainly among three activities, land preparation (20 percent), handweeding (20 percent), and harvesting and processing (46 percent). The total labor input per hectare for WSR was found to be 70.8 mandays.

For TPR, the labor distribution is somewhat different. The transplanting operation becomes the major user of labor (39 percent), compared to land preparation (17 percent) and harvesting (32 percent). The total labor input for TPR average 93.7 days per hectare, about 25 percent more labor intensive than WSR with not that much of a yield advantage.[4/] Therefore, wet seeding has replaced transplanting as the principal rice crop establishment technique.

3/ This is true to a much greater extent in the rainfed areas than in the irrigated areas.

4/ TPR yields with modern varieties average 2.5 t/ha, while those of WSR have averaged 2.4 t/ha.

Sources and Uses of Cash

Cash receipts by source

There were 5 principal sources of cash farm income, each of which is briefly discussed below:

Crop sales. Proceeds from the sale of crops provided 38 percent of the total cash received by farmers. The major source of crop income was from rice production, the bulk of which is normally sold shortly after harvest.

Livestock. Proceeds from livestock sales represent 12 percent of total cash inflow. Livestock is sold mainly during the months of June to August as a source of cash to purchase necessary crop inputs or to replenish diminished food supplies.

Credit. Credit represents 12 percent of total cash inflow, and is concentrated in the months of June to August when loans are used for first rice crop activities. The major sources of credit are private parties (neighbors, relatives) and rural credit institutions. The official interest rate for bank credit was 12 percent, but there have been a number of problems associated with bank lending in the area. First, the loan application process is long and complicated, and often the loans are approved and disbursed long after the funds are needed. For this reason borrowing on informal credit markets is quite common, though the nominal interest rate may reach as high as 50 percent. Borrowing of this type is for consumption as well as production, and is often repaid in kind, after the rice harvest.

Off-farm income. Cash received from agricultural activities on other farms constitutes 3 percent of cash income, earned mainly through wages received for transplanting.[5/]

Non-farm income. Non-farm income includes salaries and wages, buy and sell activities, and contributions from family members working in other occupations. These three sources combined represent 35 percent of the total cash inflow. The contributions category alone represents 20 percent of total cash income, received mainly from children working in domestic employment in Manila or overseas.

Cash expenditures

The five major uses of cash are associated with purchases of food, agricultural inputs, livestock, household items and education. Farmers allocate an average of 30 percent of their total cash outlays to food, 31 percent to crop inputs, 8 percent for household items, 7 percent for education, 3 percent for livestock purchases, and 21 percent for other items. Food purchases are distributed evenly throughout the year, as are household expenses and purchases of other items. Purchases of crop inputs and educational expenses (tuition, books, uniforms, etc.) tend to take place on a more seasonal basis associated with school and crop calendars.

Use of Fixed Capital Inputs

In recent years, there has been an increasing use in the Iloilo area of capital inputs, principally hand tractors and mechanical threshers.[6/]

5/ Most off-farm income in non-cash, received in kind (rough rice) after harvest.

6/ Hand tractor services normally receive a cash payment, while thresher services are paid in kind (harvest share).

Such use, however, is concentrated among the farmers with access to irrigated land, as multiple cropping is highly feasible and timing of crop activities becomes a critical factor. Most farmers are not able to purchase their own machines, but can readily hire them on a contract basis.[7/] Hand tractors replace animal traction and reduce land preparation time. Threshers reduce harvest time and replace human labor, thus causing a reduction in payment to community hired labor per harvest. It appears, however, that the loss of income to hired laborers is more than compensated by the increased number of harvests that mechanization has provided the opportunity for.

Due to the reduced potential for multiple rice cropping, machinery use is much less common in the rainfed area. Those farmers that do utilize machinery tend to concentrate its use on the lowest areas with greatest multiple rice cropping potential.

7/ Some of the more wealthy residents of the area have gone into the business of providing machinery services to farmers who cannot afford to purchase their own machinery.

APPENDIX D

APPENDIX D

CLIMATOLOGICAL EFFECTS ON RICE YIELDS

The two major climatological factors affecting rice yields are rainfall and solar radiation (IRRI, 1976). In general, an increase in both factors has a positive effect on yields. Normally, however, an increase in one factor implies a decrease in the other, since clouds necessary for rainfall reduce the intensity of solar radiation. Furthermore, periods of high solar radiation intensity contribute to moisture loss by preventing rainfall and by promoting loss of field moisture through evaporation and plant transpiration.

The yield data from Table 6.6 for three rainfall termination situations on the plain landscape position is represented in graphic form in Figure D.1. Once the wet season commences, conditions are more or less homogeneous in terms of amounts of rainfall and the incidence of solar radiation. Therefore, the yield expectations are fairly constant. When the frequency of rains begins to decrease, solar radiation increases, with a positive effect on rice yields through increased plant photosynthetic activity. Due to the high moisture retention capacity of heavy soils in the lower, more level areas, moisture stress will not initially cause yield reduction to occur. Therefore, the net effect on yields will be positive. As the frequency and intensity of rainfall decrease, and solar radiation begins to hasten water loss through evaporation, moisture stress will begin to become a significant factor causing yields to decline. The rates at which yields increase and decline depend upon the particular rainfall pattern occuring during the growing season in question.

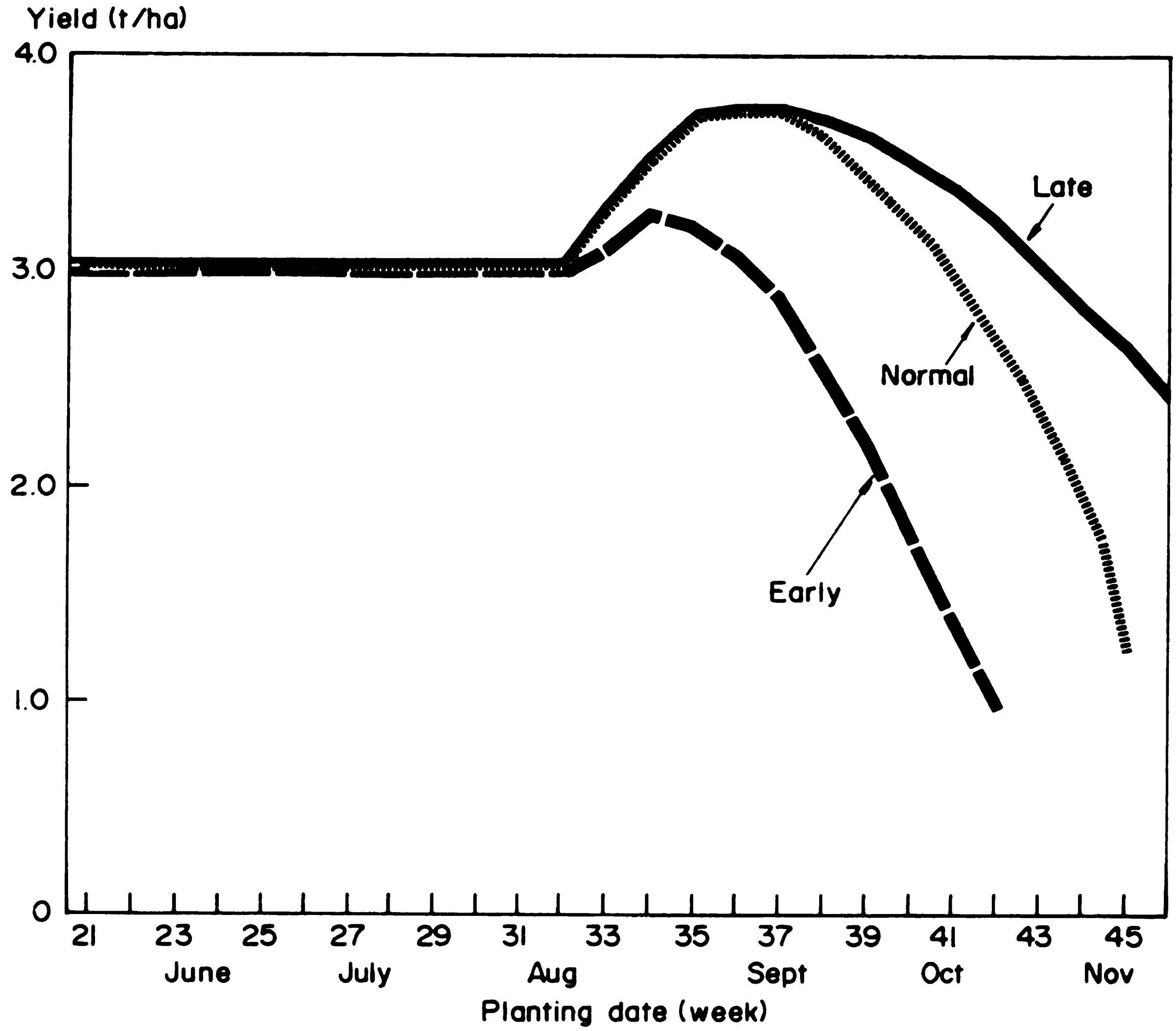

Figure D.1. Relationship between grain yield and date of planting for fields in the plain-plateau landscape position for three rainfall termination situations.

The general relationships just described hold also for the sideslope landscape position (Figure D.2). The yield curves for the sideslope position follow the same general trend as do those for the plain-plateau, except that yields decline sooner and at an increased rate. Water leaves paddy fields in sloping areas through surface runoff and seepage and percolation at high rates, thus exposing rice crops to moisture stress soon after the decline in rainfall. The positive effect of solar radiation is quickly overcome by the negative yield effect of moisture stress. Therefore, yields tend to fall sooner and more sharply on fields with light soils in sloping areas.

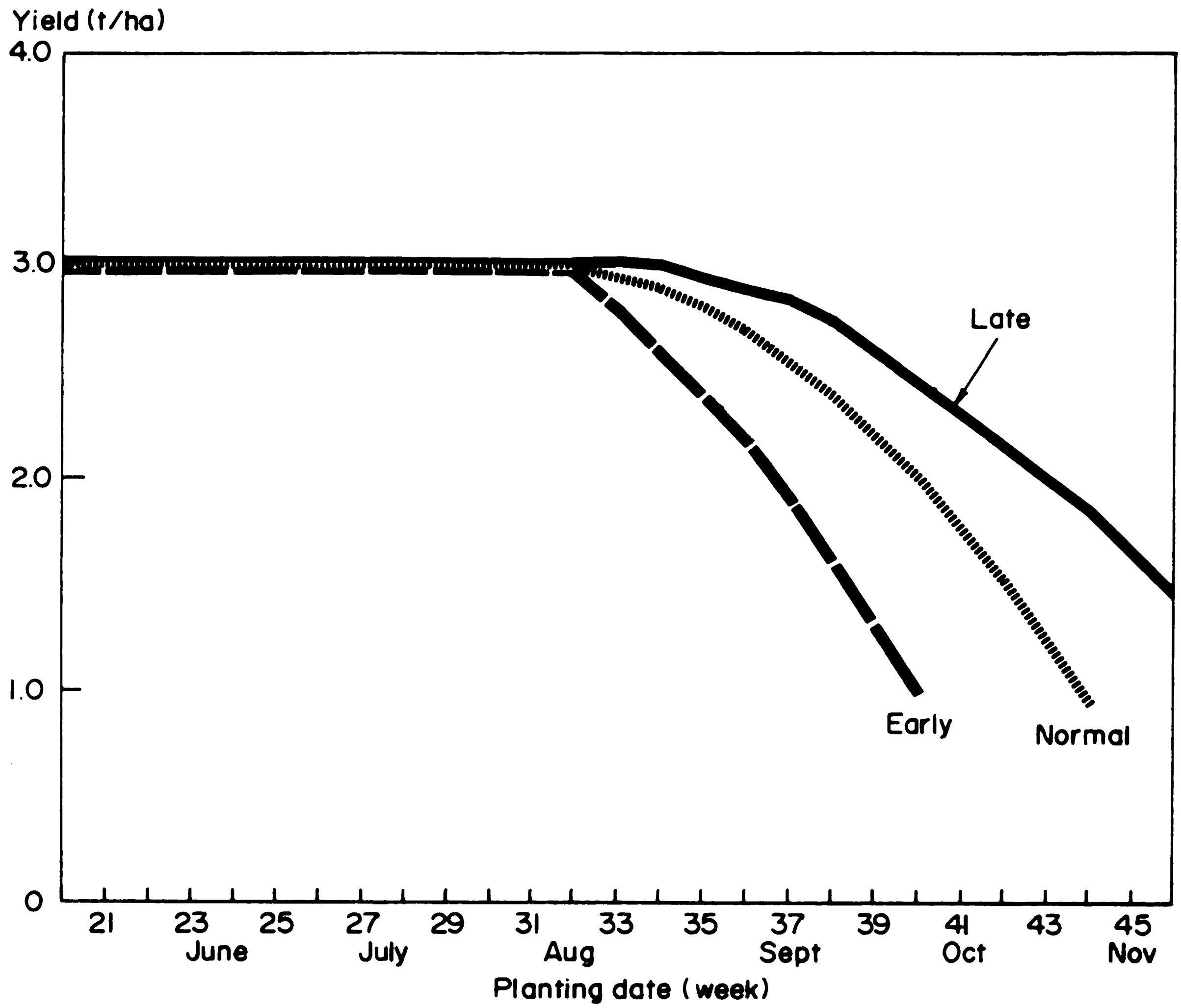

Figure D.2. Relationship between grain yield and date of planting for fields in the sideslope landscape position for three rainfall termination situations.

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