Improvement of Postharvest Grain Systems

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EVALUATION OF ALTERNATIVE POST-PRODUCTION TECHNOLOGIES IN CENTRAL LUZON AND BICOL REGIONS, PHILIPPINES

KSU
KANSAS STATE UNIVERSITY

FOOD & FEED GRAIN INSTITUTE
MANHATTAN, KANSAS 66506

REPORT SUMMARY

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Authors: Dr. Zenaida F. Toquero, Dr. Richard Phillips, Agricultural Economics Department and Dr. John R. Pedersen, Grain Science and Industry Department, Kansas State University, Manhattan, Kansas.

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SUMMARY STATEMENT

The study objectives were to (a) examine the nature, patterns, magnitudes, and causes of losses under various systems of post-production technology and management, and (b) determine the factors that explain the choice of technology in rice post production. The data used in the study are based on a series of field level trials conducted by the Department of Agricultural Engineering of the International Rice Research Institute in Central Luzon in 1975-76 and in the Bicol Regions in 1976-77. These field trials were carried out to assess the performance of the IRRI-designed axial-flow thresher and twin-bed batch dryer as compared to traditional methods practiced in the area.

General Linear Model of the Statistical Analysis System was used to determine the physical and quality detorioration response functions for paddy and milled rice. Inferior quality characteristics of paddy and milled rice such as impurity, cracked, damaged, fermented, and chalky kernels were found to be associated with a reduction in the quantity, quality and market grade of milled rice. Timeliness in the performance of subsequent post-production tasks as well as the type of machine or equipment used likewise influenced variability in rice recovery and grade.

Comparative rate of return (CRR) on added capital investment was used to measure the economic potential of alternative post-production systems over that of the traditional systems. The alternative combining the axial-flow thresher with sun drying exhibited the highest CRR in spite of the

foregone quality price premiums largely because of the low capital and operating cost of traditional sun drying coupled with efficient performance of the axial-flow thresher. The second highest CRR value was obtained from systems using the axial-flow thresher and the batch dryer. Alternatives where traditional methods of threshing and cleaning are combined with mechanical drying showed relatively low comparative rate of return even with substantial quality premiums. High capital outlay and operating expenses incurred in mechanical drying contributed to this low CRR.

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Prepared by

Dr. Zenaida F. Toquero
Dr. Richard Phillips
and
Dr. John R. Pedersen

Prepared for the
AGENCY FOR INTERNATIONAL DEVELOPMENT
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at the

FOOD AND FEED GRAIN INSTITUTE
Kansas State University
Manhattan, Kasnas 66506

Dr. Charles Deyoe, Director

Contribution Number 84-203-D, Kansas Agricultural Experiment Station
Kansas State University, Manhattan, Kansas

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ACRONYMS

ACA	Agricultural Credit Administration
ADRC	Agricultural Development Council of Rizal
AMC	Area Marketing Cooperative
ASEAN	Association of Southeast Asian Nations
BRBDP	Bicol River Basin Development Program
BULOG	National Logistic Agency, Indonesia
CB-IBRD	Central Bank of the Philippines - International Bank for Rural Development
CRR	Comparative Rate of Return
CSIRO	Commonwealth Scientific and Industrial Research Organization
CIDA	Canadian International Development Agency
CFTRI	Central Food Technological
DBP	Development Bank of the Philippines
ESCAP	Economic and Social Commission for Asia and the Pacific
FACOMA	Farmers Cooperative Marketing Association
FAO	Food and Agriculture Organization of the United Nations
FSDC	Farm Systems Development Corporation
GASGA	Group for Assistance on Systems relating to Grain After harvest
GLM	General Linear Model
GTZ	German Agency for Technical Assistance
IDP/NE	Integrated Development Project for Nueva Ecija
IRRI	International Rice Research Institute
IDRC	International Development Research Center, Canada
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres
IRR	Internal Rate of Return

KADA	Kemubu Agriculture Development Authority
KSU-FFGI	Kansas State University, Food and Feed Grains Institute
KIT	Royal Tropical Institute
LPN	Lembaga dan Beras Negara
LPP	Lembaga Persatuan Peladang
MADA	Muda Agriculture Development Authority
MARDI	Malaysian Agricultural Research and Development Institute
NAPHIRE	National Post Havest Institute for Research and Extension
NPV	Net Present Value
NAS	National Academy of Sciences
NFA	National Food Authority
NSTA	National Science and Technology Authority
PCARD	Philippine Council for Agricultural Research and Resource Development
PMB	Paddy Marketing Board
RCA	Rice and Corn Authority
SN	Samahang Nayon
SEMEO	Southeast Asia Ministers of Education Organization
SEARCA	Southeast Asian Regional Center for Agriculture
SGC	"Save Grain Campaign"
SAS	Statistical Analysis System
TPI	Tropical Products Institute
UNU	United Nations University
USDA	United States Department of Agriculture
USAID	United States Agency for International Development
WARDA	West African Rice Development Association

PREFACE

This research report has been prepared from a dissertation research project carried out by Zenaida Toquero while attending Kansas State University on a graduate research assistantship. Miss Toquero completed her doctorate studies at KSU on leave from her research position in the Department of Agricultural Engineering at the International Rice Research Institute (IRRI) at Los Baños, Philippines under memorandum of agreement between the IRRI Department of Agricultural Engineering and the KSU Food and Feed Grain Institute.[1] The memorandum of agreement provided use of the IRRI data for the study by Kansas State University to the mutual benefit of both institutions. This report is an outgrowth of that agreement under research by the Food and Feed Grain Institute at KSU supported largely by Cooperative Agreement AID/DSAN-CA-0256.

The quantitative data on physical loss and quality deterioration of paddy and milled rice during alternative post-production operations were developed from a series of field-level trials conducted by the IRRI Department of Agricultural Engineering in Central Luzon in 1975-76 and Bicol in 1976-77. These trials were carried out to assess the performance of the IRRI-designed axial-flow thresher and twin-bed batch dryer as compared to traditional methods practiced in the two regions. In this study the observed losses and quality deterioration of individual post-production operations under alternative techniques were regrouped for quantitative analysis of physical and economic performance of alternative rice harvesting, threshing, drying and handling practices. Multiple regression analysis was used to measure the impacts of the various factors associated with the extent of threshing loss, head rice recovery, total milling yield and market grade of milled rice in alternative post-production systems. Discounted cash flow analysis of comparative rate of return (CRR) on added capital investment was used to evaluate the improved systems compared to traditional systems in the two regions of the Philippines.

Physical post-production losses were measured as (1) loss of paddy grains and (2) loss of milling recovery when the remaining paddy is milled, standardized for moisture content and purity. Lower physical losses were associated with use of the axial-flow thresher and batch drier (Table 2), with timely operations (Table 3), and with favorable moisture content, sound kernels, purity and other quality characteristics of the paddy at harvest (Tables 9 and 10). Post-production losses of quality were measured as (1) reduction in the percentage of head rice recovery and (2) reduction in numerical grade of milled rice. Lower quality losses were associated with use of mechanized techniques (Table 4), with timely operations (Table 5), and with favorable characteristics of the paddy at

[1]The authors are indebted to Mr. Bart Duff of IRRI for his leadership in negotiating the memorandum of agreement and his counsel through the course of the study. The relationship has been rewarding to the authors, but they accept full responsibility for the methodology, interpretations and recommendations expressed herein.

harvest, such as maturity, moisture content, and absence of cracked, chalky and fermented kernels (Tables 11 and 12).

Comparison of the alternative post-production systems with traditional systems shows that the most profitable system for rice farmers is the axial-flow thresher combined with sun drying. In spite of forgone quality premiums under this system, the annual comparative rates of return on additional investment exceed 100 percent (Table 19). The comparative rates of return for the fully-mechanized system range from 34 percent to more than 50 percent, depending upon the levels of market premiums for milling quality and wage rates for harvesting labor (Table 16). Alternatives combining traditional harvesting methods with mechanical drying are infeasible for Filipino farmers unless they receive a substantial market premium for the mechanically-dried paddy. (Tables 22 and 23).

The findings indicated sound justification for continued expansion in the use of axial-flow paddy threshers in the Philippines. Mechanical drying, although effective for reducing post-production losses of quantity and quality, appears to have limited potential at the farm level. Because they receive the benefits of higher milling yields associated with mechanical drying, it is the commerical rice millers who have economic incentive to expand the use of mechanical dryers. Paddy price premiums of some two percent for mechanical drying would be required to make the use of batch-dryers financially attractive to producers.

CHAPTER I

INTRODUCTION

Importance of the Study

Rice is by far the most important food crop in the Philippines. To Filipinos, rice is life, politics and economics (1). It is the country's staple food, and 80 percent of the population depends on rice in one way or the other for its livelihood. Every government administration has used self-sufficiency in rice as an avowed goal and political promise. Rice must continue to play a major role in the improvement of the Philippine economy. Rice output must be doubled in the next twenty to twenty-five years just to keep pace with predicted growth of population and consumer demand. This can be achieved only by mounting accelerated production programs to increase rice output.

Increased rice output can be achieved in several ways. One is by expanding the area planted to rice. Another is through infrastructure development such as irrigation to support improved technology and increased productivity. Reduction in post-production losses will likewise increase net output for consumption.

Considerable attention has been given to increasing food production through the development of high yielding varieties and increasing the availability of complementary inputs such as water, fertilizer, insecticides, and fungicides. Much less effort has been put into the postharvest sector, where the need is to insure that all of the grain produced is safely harvested, and that the harvest is preserved, processed and distributed to meet the requirements of consumers.

Ironically, the early momentum to realize the potential of this neglected dimension was generated by the promise of a surplus, not the existence of deficit. It was not until an increased volume of grain began moving into the market as a result of increased production that more attention was given to this area. The whole gamut of the marketing problems associated with moving, processing, buying and selling larger quantities of grain has become the second generation problem of the green revolution (2).

The strongest support for a coordinated postharvest program came from the resolution of the special session of the United Nation's General Assembly in 1975, calling for a 50 percent reduction in postharvest food losses by 1985, and the cooperation of all countries in attaining this objective. This was followed by the establishment by the Food and Agriculture Organization (FAO) of a special fund for the prevention of postharvest losses. At the regional level, the Southeast Asia Cooperative Post Harvest Research and Development Program emerged.

A number of international agencies are engaged in postharvest food loss reduction programs in developing countries. Many of these agencies work closely together with coordination of efforts at many points. In the ASEAN (Association of Southeast Asia Nations) region, individual countries have for several years undertaken a variety of programs to reduce postharvest losses, particularly for food grains. Major focus has been on rice, the basic staple food of the population of the region.

In spite of the growing body of literature dealing with the issue of postharvest grain losses, there is need to plan, implement and interpret additional research in this area of inquiry. There is still much that is not known about patterns, magnitudes, and causes of losses in the sequence of post-production operations. The operations (both at the field and processing stages of the post-production system) are interdependent, making evaluation in discrete operations difficult and the results often inconclusive in pinpointing the nature and characteristics of losses. Another major justification for the continued research on postharvest losses lies in increased economic incentive. With increased grain yields in countries adopting modern varieties, fertilizer, chemicals and expanded irrigation, higher absolute losses occur, thus raising the value of output and making recovery economically more important. Finally, characteristics of the environment within which losses occur are changing. New grain varieties with differing dates of maturity and milling characteristics coupled with modified methods of management make precise recommendations based on previous studies largely inappropriate (3).

General Review of Relevant Studies

The seriousness of the problem of postharvest foodgrain losses has been discussed at numerous meetings, conferences, and symposia at the national as well as international levels. Many studies for assessing postharvest losses have been conducted at various levels by institutions throughout the developing world. And during the last decade, a very large body of published materials dealing with the many aspects of postharvest food technology has emerged.

While numerous references to studies on losses and loss reduction can be found, all too often referenced studies are widely scattered, unpublished or difficult to locate. Frequently, they are not readily identifiable by title as relevant to postharvest technology. Very few of these document results are based on comprehensive research, experiments or surveys. Some of the loss estimates are based on guesses, others on limited observations and/or poorly-designed studies. As a consequence, their validity and relevance is questionable.

In this section some attempt is made to review available literature on the subject published during the last decade. However, since the number of publications is too large to permit exhaustive review, only such literature as was available to the authors and of greater relevance to the problem being studied has been referenced in this study.

Hall (4) prepared a manual on handling and storage of foodgrains in tropical and sub-tropical areas. The study was based on information collected from research workers in Africa and other developing countries as well as organizations concerned with storage problems. The manual discusses in detail the principles of handling and storage of cereals, legumes and oilseeds. It sets out the causes of grain loss, deterioration and contamination, the methods of drying and storage, the design of storage facilities and methods of controlling fungus, insect and rodent.

In 1975, a survey was carried out by the survey team of the Directorate of Food Crops Economics, Indonesia in several regions of East and West Java. Results of the study indicate that most of the dryers are underutilized because of technical, economic and social reasons (5).

In 1977, the FAO in cooperation with the Government of Malaysia and the Food for the Hungry, Inc., hosted an Action-Oriented Field Workshop in Kedah, Malaysia for the prevention of postharvest losses in rice. Recommendations and suggestions which came out of the workshop were focused on the methodology for assessing quantitative and qualitative losses in rice post-production operations. Twenty-nine papers were presented and discussed at the workshop (6).

Harris (7) recommended that specific in-depth studies be made to identify and measure losses at each stage of the post-production sequences of operations. He thinks study of loss assessment should be a collaborative work between scientists of multidisciplines such as statistics, entomology, anthropology, sociology and economics.

FAO (8) summarized the reports submitted by their country representatives on a survey of postharvest crop losses in the developing countries. Commodities discussed in the report include cereals, fruits, vegetables, animal products, fish and crustacea, and miscellaneous commodities. Priorities for the reduction of these losses were also proposed in the report.

Existing work and information about losses of major food crops and fish in developing countries are also summarized in the report prepared by the National Academy of Sciences (9). Some of the economic and social factors involved, needs and suggested policies and programs for the less developed countries and technical assistance agencies are also discussed in this study.

In 1978, staff of the Western Regional Center, Sciences and Education Administration through the initiative of the United States

Agency for International Development conducted a worldwide field investigation to update knowledge on rice postharvest practices in developing countries (10). Based on data obtained from interviews and visits with research workers, institutions, and companies involved in grain postharvest studies, they presented an intensive state-of-the-arts review of rice postharvest losses, the pattern and magnitude as well as causes of these losses, actions undertaken to prevent their occurrence, and some recommendations for future international assistance. The publication contains a selected bibliography of more than 200 publications in the area of postharvest technology.

The book developed and compiled by Harris and Lindblad (11) for the American Association of Cereal Chemists contains articles and materials contributed by scientists of multidisciplines. It provides an overview of the major requirements in planning and organizing a loss assessment study, the complex multidisciplinary factors that have to be considered, and the statistical methodology for sampling and interpretation of results are discussed in the book. In terms of loss assessment, the book provides detailed guidelines for assessing quantitative and qualitative losses during storage, but only brief discussion with very little detail on assessing losses during threshing, drying and milling. The book also systematically reviews the concepts, definitions and measurement techniques in postharvest loss assessment.

Sarath Ilingantileke (12) used a systems analysis of the in-field post-production operations in Sri Lanka for two harvesting seasons, Yala and the Maha. Grain losses and technology were investigated and evaluated in relation to climate and labor availability. Field measurement data were analyzed and equations were developed for use in formulating a systems model. The model was then used to simulate response of selected rice varieties to alternative technological practices.

A similar simulation study was conducted by Habito and Duff (13) in a typical two hectare farm in Laguna province, Philippines to compare quantitative and qualitative losses associated with mechanized and non-mechanized farm production techniques (harvesting, threshing, cleaning and drying). In the simulation model, stochastic variables such as availability of labor and weather were used to test influences on the final returns obtained under alternative post-production techniques. In the choice of technique decision framework, paddy quality was used as an important criterion.

The SEARCA Technical Team (14) prepared a discussion paper on postharvest programs, issues and problems in the ASEAN countries of Indonesia, Malaysia, Philippines, Singapore and Thailand. The paper provides an overview of the postharvest systems and discusses priority areas for current and future problem-solving initiatives both by SEARCA and individual member countries.

An FAO Manual (15) provides guidelines on statistical methodology for assessing, sampling and collecting data on postharvest foodgrains losses. Concepts, definitions, and measurement techniques of quantitative and qualitative losses in various post-production operations from harvesting to processing and distribution are discussed in the manual.

As FAO consultant, Schulten (75) critically reviewed the loss assessment activities of completed and on-going FAO Prevention of Food Loss (PLF) Projects in 1982. This review was discussed by GASGA representatives and technical FAO staff with recommendations on the form and scale of loss assessment activities to be included in loss reduction projects.

The Southeast Asia Cooperative Post Harvest Research and Development Program has sponsored a series of technical workshops with the cooperation of host institutions in the Asian region. Papers presented during these workshops are compiled and published as Proceedings.

The first annual workshop was held in Bangkok, Thailand June 10-12, 1978 with the Division of Agricultural Engineering, Thailand. Twenty-two papers were discussed and presented at this workshop dealing with the various aspects of postharvest operations, including milling, drying and storage, as well as research and extension.

In January, 1979, the second workshop was held in Jakarta, Indonesia with the cooperation of the National Logistics Agency (BULOG) and the Department of Agriculture, Indonesia. The proceedings of the workshop cover the post-production system's capability to deliver output subject to the influence of engineering, economic, sociological and environmental factors. Twenty-two papers were discussed and presented during the seminar.

The third workshop was held in Kuala Lumpur, Malaysia in cooperation with the Ministry of Agriculture, Malaysia, the Malaysian Agricultural Research and Development Institute (MARDI), Lembaga Padi dan Beras Negara (LPN) and Lembaga Persatuan Peladang (LPP). The focus of the workshop was on the improvement of grain quality.

The 1981 Postharvest Workshop was held in Manila, Philippines through the cooperation of the National Postharvest Institute for Research and Extension and the National Food Authority. It was attended by 133 delegates from the ASEAN countries, Australia, the United States, England, Korea, Bangladesh and India. Thirty technical papers were presented along the line of improvement of postharvest facilities and systems including threshing, handling, drying, milling and insect and rodent control.

Studies on Rice Post-Production Technology by IRRI

Rice post-production technology is a major research area in the Department of Agricultural Engineering of the International Rice Research Institute (IRRI). In addition to machine design, testing and evaluation, several feasibility and socio-economic studies have been conducted in the Department to (a) inventory existing post-production practices and technology, (b) examine the degree of machine adoption and utilization, (c) evaluate the technical and economic performance of these machines, (d) determine the costs and benefits associated with its use, and (e) study farmers' attitudes and preferences in the use of alternative post-production techniques.

To examine post-production systems currently existing in the Philippines, a comprehensive survey was undertaken in 1973-74 in three regions in the country--Central Luzon, Bicol Region and Southern Tagalog--representing three of the major rice producing areas in the country (16). One hundred and eighty rice mills and approximately 600 rice farmers were surveyed to inventory existing post-production practices. Harvesting and threshing have been identified by Filipino farmers as major problem areas in rice production. To determine the impact of post-production operations on the quality of paddy and milled rice, samples of paddy were taken from 111 rice mills in the three regions studied. The samples were analyzed and graded according to the six grade categories established by the Philippine government. Results of the analysis showed only one-third of the samples falling into the upper three classifications categorized as high quality. The bulk were graded as low quality and one-third fell into the lowest or sub-standard category. These results attests to the fact that a number of factors causing losses occur in operations preceeding the actual milling of paddy.

Studies by Alkuino (17), Getubig (18) and Toquero and Duff (19) have examined characteristics of the rice marketing and processing industry in the Bicol Region. These studies indicate that the region has a significant volume of unutilized milling and storage capacity and that current farm practices are not conducive to the production of high quality paddy or milled rice. A number of technical inefficiencies in components of existing systems appears although by economic criteria, the industry appear to perform rationally.

Habito (20) examined the problem of choosing the appropriate technologies in rice harvesting, threshing/cleaning and drying operations in the Philippines. Seventy-two different systems or combinations thereof were evaluated for their relative technical efficiencies using the isoquant-isocost approach suggested by Timmer (21) and the comparative cost analysis undertaken by Boon (22). Only seven threshing-cleaning combinations were singled out as technically efficient and logical alternatives for more intensive economic evaluation. Results of the study indicate that labor intensity-capital productivity criteria alone are insufficient for making a valid choice of techniques inasmuch as factor costs are ignored. As a result, the tradeoff between capital savings and increased employment is neglected. Furthermore, there are other factors not accounted for in the empirical analysis that have important roles in the choice of techniques. These include technical considerations, institutional factors, and technology impact on labor absorption and employment.

In 1977-78, a study was undertaken by Ebron, Takai, and Duff (23) to provide a detailed assessment of farm level storage practices in selected provinces of Luzon and Iloilo. To attain this objective, a survey was conducted in the study areas and a carefully controlled series of laboratory experiments were carried out to evaluate grain quality and deterioration effects due to fungi and insects. The study examined the disappearance pattern of paddy from storage, the condition and quality of grains in storage, deterioration patterns and possible sources of grain losses, and the techno-economic background influencing the use of particular storage practices.

Juarez (24) examined different issues relating to increased and continued adoption of mechanical threshers since 1976. The study was conducted in the provinces of Iloilo and Laguna, Philippines to analyze the distributive and output effects of adopting mechanical threshers. The reasons for and against the use of threshers, the institutional arrangement for harvesting-threshing in both areas, and impacts of thresher adoption on turnaround time, yield, income, farm size, tenure and prestige were also discussed in this study.

As a follow-up to the above mentioned study, Juarez and Pathnopas (25) made a cross country comparison of thresher adoption and use in Thailand and the Philippines. The history of thresher adoption and diffusion in both countries was traced and the factors affecting adoption and the different measures of costs and benefits were analyzed.

Since 1973, the Department has likewise conducted surveys, field experiments, and farm level field trials to assess and evaluate the role of post-production operations in determining the nature and magnitude of quantitative and qualitative losses in rice.

A field study undertaken by Samson and Duff (26) quantified paddy loss characteristics which occur in the harvesting and threshing operations. The study consisted of three phases: The first was a replicated experimental trial conducted on the IRRI farm during the 1972 dry season. The second and third stages consisted of replicated field sampling techniques conducted during the 1972 wet and 1973 dry seasons in Gapan, Nueva Ecija, Philippines. Results of the study showed that the range of losses in the harvesting process itself is not great, but that it can be significant if the yield level is high. The levels of loss were particularly sensitive to the date of harvest which, in turn, is dependent upon the moisture content of the grain. There were also significant differences in loss levels between wet and dry seasons and between different varieties.

Based on the results of the above mentioned research, a series of farm level trials was conducted in Central Luzon and Bicol Regions of the Philippines from wet season 1975 to the dry season of 1977 to assess the impact of alternative systems of rice post-production operations. Four systems of technology involving alternative combinations of threshing and drying techniques were utilized (See Figure 1, Chapter II). System I exemplified the traditional system commonly practiced in the area. Mechanized technology was exemplified in System IV where the IRRI-designed axial-flow thresher and twin-bed batch dryer were introduced. Systems II and III combined elements of traditional and mechanized systems in the threshing and drying operations. Composition of farms included in the trials is given in Table 1.

Table 1. Characteristics of villages included in the post-production pilot trials, Central Luzon and Bicol Region, Philippines, 1975-1977.

Location	Season	No. of Cooperators	No. of Plots	Ave. area (m^2/plot)	Variety
CENTRAL LUZON (Nueva Ecija)					
Soledad, Sta. Rosa	Wet	5	80	771.4	IR20 IR26 IR1529 IR1561
Malapit, San Isidro	Wet	6	46	1423.2	IR26 IR30 IR579 IR1529 IR1561
Polilio, Cabanatuan	Dry	4	42	1242.3	IR26 IR30 C4-63G
Sta. Cruz, Zaragosa	Dry	5	22	1350.27	IR747 IR30 IR20
BICOL REGION					
Libon, Albay	Wet	3	25	1209.197	C4
	Dry	5	32	1739.392	C4 IR26 Peta
San Jose, Camarines Sur	Dry	5	55	1037.914	C4 IR20 IR26 IR30
Buhi, Camarines Sur	Dry	4	39	1017.041	C4 IR26

Preliminary results from village level field trials in Central Luzon have been summarized in a number of working papers issued by the Department of Agricultural Engineering and listed in the attached bibliography (27 and 28). Results of the study in Bicol were reported in the publication "The Technical and Economic Characteristics of Rice Post-Production Systems in the Bicol River Basin" (29). Analysis in these field trials centered mainly on the measurement of quantitative and qualitative losses between alternative systems. Some evaluation of costs and benefits incurred was included, but the issues involved in making a choice between alternative techniques were not addressed in depth.

Scope and Objectives of the Present Study

It is the purpose of the present study to conduct in-depth analysis and evaluation of these alternative post-production systems. The four post-production systems considered in the pilot trials were further segregated for each of the specific post-production tasks. Harvesting, handling and drying operations were categorized according to timeliness in the performance of each tasks. Under "traditional" threshing and cleaning, it was noted that different tools or equipment were used in different locations thus allowing a further sub-grouping in these two operations. The IRRI study made no distinction among these traditional techniques.

The following are the sub-categories used under each specific post-production tasks:

Harvesting

a) immediate harvest (i.e. accomplished within the day)

b) delayed harvest (took more than one day to finish job)

Handling

a) timely handling (done immediately or simultaneously with harvesting)

b) delayed handling (delayed or staggered bundling, hauling, stacking)

Threshing

a) threshing frame (hampas)

b) flail or stick

c) axial-flow thresher

Cleaning

a) winnowing basket or sieve (bilao or bithay)

b) wooden winnower (known locally as hungkoy)

c) axial-flow thresher

Drying

a) timely sun-drying

b) delayed sun-drying

c) timely batch drying

d) delayed use of the batch dryer

The choice of alternative techniques in harvesting, handling, threshing, cleaning, and drying in the two regions are examined in the light of the technical, economic, social, cultural, institutional, environmental and other factors as they influence the decision-making process.

This study is perhaps more problem-seeking or investigating than problem-solving since it is an exploratory one. Through the analysis of data generated from the village level field trials, the study attempts to provide partial answers to the following questions:

1. What is the range of alternative technologies currently available in rice harvesting, handling, threshing, cleaning, and drying in the study area?

An extensive state-of-the-arts review of existing post-production practices in the area will determine the relevance of the entire choice of technology issue. For the issue to be relevant, there should be a range of alternative technologies embodying significantly different technical and economic characteristics from which a choice can be made.

2. What are the nature, patterns, magnitudes and causes of losses under various systems of post-production technology and management?

While there is a need to accurately measure losses in alternative techniques to justify choice, it is just as important that loss assessment studies should lead to a better understanding of the complexity of the concept of "loss". There is no agreed definition of "loss" because of its varied nature; loss may refer to loss in weight, quality, nutritive value, market value, etc. Each of these types of losses may have different significance that varies with people, time and place and in the face of existing methods and conditions of evaluation.

3. What are the factors that explain the choice of technology in rice post-production systems?

The post-production system is a complex interaction of numerous factors which frequently result in loss, be it food, effort, or efficiency. The method of quantifying and qualifying these factors (e.g. technical, economic, social, cultural, institutional, etc.) must be examined and analyzed in order to fully understand the varying efficiencies and/or inefficiencies of alternative systems rather than simply estimating relative weight loss.

CHAPTER II

STUDY DATA AND RESEARCH METHODOLOGY

Field Trial Design and Methodology

Data used in this study were taken from the results of the field level trials conducted by the Department of Agricultural Engineering of the International Rice Research Institute in Central Luzon and Bicol Regions from 1975 to 1977.[1] These include the input-output data for the different post production operations such as labor requirements, expenditures (fixed and operating), quantitative and qualitative losses, outputs or yields, and results of the laboratory analysis for paddy and milled rice.

To supplement information from the field trials, rice farmers were interviewed regarding their harvesting, threshing, drying, storage, milling and trading practices as well as their attitudes and preferences in the choice of alternative post production techniques. Production and disposal were asked in order to estimate respondents' marketable surplus of rice.

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[1]The project in Central Luzon was the senior author's major project while working in the Department of Agricultural Engineering at IRRI. In the Bicol project, she was instrumental in the conceptualization of the research design, selection of the project sites and development of the field interviewing and evaluation format. In recognition of her role, an agreement was signed between the Food and Feed Grain Institute of the Kansas State University and the Department of Agricultural Engineering, International Rice Research Institute providing use of the data generated from the field trials for further research at Kansas State University.

Information on institutional arrangements was obtained through personal interviews with farmers, hired laborers, machine owners, operators and other resource persons. Additional information relevant to the analysis was taken from secondary sources such as published materials, censuses and statistics, and on-going research for the study areas.

The Study Areas

The great plain of Luzon is the most important and largest single plain in the archipelago. It is a highly developed agricultural region where a large percentage of the Philippine population is found. Central Luzon is known as the "rice granary" of the Philippines. It encompasses the provinces of Nueva Ecija, Pampanga, Bulacan, Tarlac, Zambales and Bataan.

The central plains is extremely flat with a land area of 18,280 sq km. The Central Luzon basin has a highly seasonal distribution of rainfall. It is shielded by the Caraballo mountains when the north and northeast trade winds blow, and by the Zambales mountains the remainder of the year. There is a pronounced dry season from November to April. However, the southwest monsoon trade winds bring rains from June through October. The mean monthly rainfall over 20 years averages 5 mm in January and 383 mm in August. In combination with irrigation, farmers design their cropping sequences to make full use of the rainfall pattern, planting their first crop in June and their second in December.

In Central Luzon plains, rice is the most important crop, and rice growing is the basic farming pattern. The region accounted for 14 percent of the country's harvested area in 1974-75 and 18 percent of the national rice production in 1974-75 (30).

Nueva Ecija, one of the postharvest project sites, is the seat of various agricultural development projects including the Upper Pampanga River project which includes Pantabangan Dam, the largest single infrastructure project in the Philippines. Nueva Ecija is located in the heart of the central plain lying north in the Caraballo and Sierra Madre mountains. It is bounded by Bulacan on the south, Nueva Vizcaya and Pangasinan to the northeast, Pampanga to the southwest, Tarlac on the west and Quezon on the east.

Nueva Ecija rice farms comprise about 29 percent of the total area planted to rice in Central Luzon. It has also one of the highest yields per hectare in the country. It's land area is 5,284 sq km.

The Bicol Region, on the other hand, is in the southernmost part of Luzon. It consist of the provinces of Camarines Norte, Camarines Sur, Albay, Catanduanes, Sorsogon and Masbate. The valley of the Bicol River Basin on San Miguel is mainly important for the production of lowland rice.

Camarines Sur, also one of the project sites for village level field trials, lies in the southern part of Luzon and is bounded by the Province of Albay on the south. It lies at the very heart of Bicolandia covering a total land area of 5,269 sq km. The landscape of the province embraces the volcanic regions of its two massive extinct volcanoes and an extensive valley through which the Bicol river meanders. Two distinct seasons dominate the year-round weather condition of the province, the wet season and the dry season. The wet or rainy season is ordinarily characterized by typhoons. Camarines Sur is reported by many as the rice granary of the Bicol Region.

Another area selected for the village trials is Albay, one of the most progressive agricultural province of the Bicol Region. It lies in the central section of the southeastern volcanic region of the island of Luzon. It has a total area of 2,553 sq km. Albay's general topography ranges from level to gently sloping, rolling to hilly and mountainous. The level areas consist of the interior and the coastal plains. Two types of climate prevail in Albay. Central and eastern Albay has a very pronounced maximum rain period and no dry season while western Albay has no pronounced maximum rain and no dry season.

Village Level Trials

This section incorporates discussion of criteria and procedures followed in planning, selecting and implementing field trials.

Site Selection. The field implementation of the postharvest trials required the IRRI staff to live in the study area throughout the duration of the experiment. Site selection was partially based on a sequential series of harvesting calendars to allow a single assessment team to move from one site to another without having to manage operations at two or three sites concurrently. The selected site was required to have at least 50 hectares planted to irrigated rice and with at least two crops of rice per year.

The field trials in Central Luzon were conducted from the wet season 1975 to wet season 1976 in four municipalities of Nueva Ecija Province - - Sta. Rosa, San Isidro, Cabanatuan and Zaragosa.

In Bicol, the field trials were initiated in 1976 in two municipalities of Camarines Sur and one in Albay. In Libon, Albay, the trials were carried out for the wet and dry seasons while in San Jose and Buhi, Camarines Sur, the field trials were only for the dry season.

Selection of Farmer Cooperators. In order to insure success in the implementation of the field trials, a series of meetings were held at selected villages. The whole concept of the proposed trials and the duties and responsibilities required of the participating farmer association and selected farmer cooperators were discussed (Appendix A).

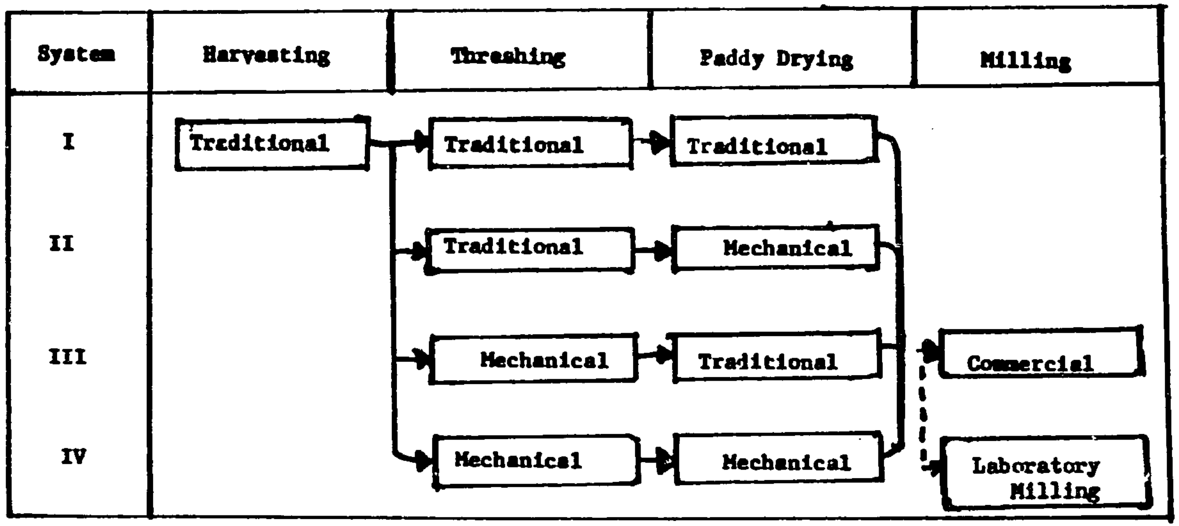
Farmer cooperators were picked from those members of the selected association who were willing and interested in project participation. Farms included in the experiment were in a contiguous area, double-cropped, irrigated and with relatively homogenous soil and yield history.

Acquisition of Postharvest Equipment. The threshers and dryers used in the pilot trials were purchased through the project fund and sold to the farmers' association selected for the field trials. An equipment purchase agreement was signed by the president of the association, the manager of the Area Marketing Cooperative (AMC) and a representative from the cooperating agency through which the project was being implemented. In Central Luzon, the project was implemented in cooperation with the Integrated Development Project for Nueva Ecija (IDP/NE). In the Bicol Region, the research was conducted in cooperation with the Bicol River Basin Development Program (BRBDP). Under the terms of the Purchase Agreement, the cooperating agency sold one axial-flow thresher and a twin-bed batch dryer to the farmers' association. The machines were amortized over a period of not more than five years with 8 percent interest charged on the unpaid balance. No initial downpayment was required from the association for purchase of the equipment. The first amortization was made after one year of custom renting the postharvest machines to members and other farmers in the area or neighboring towns. This was to enable the association to generate enough income to pay for the operating expenses and amortization without necessitating the use of the funds of the organization.

The Area Marketing Cooperative acted as intermediary or guarantor of the loan by the association from the agency. All threshing and drying

Pilot Project

Farm Level Post Production Systems



Measurements (for each system)

• Crop-cut samples • Paddy Samples • Moisture content	• Post threshing output • Paddy samples • Moisture Content	• Post drying output • Paddy samples • Moisture content	• Total Rice • Head rice • By-products

Figure 1. Alternative Farm Level Post-Production Systems.

fees (either paid in cash or in kind) collected from the use of the machine were deposited to the AMC. The AMC in turn acted as marketing agent and liquidated stocks. Forty percent of the gross income from the use of equipment was given to IDP/NE as amortization charge while 60 percent remained with the association to defray expenses on labor, fuel and oil, and maintenance.

In the Bicol study, there were no Area Marketing Cooperatives so the individual farmer association paid their amortization directly to the Bicol River Basin Development Program.

Alternative Post-Production Systems. Four systems involving alternative combinations of technology and management were utilized in the village level field trials (Figure 1). Harvesting operations in all four systems used the scythe or sickle as traditionally practiced in the area.

System I exemplified traditional technology. Threshing was entirely manual with the operator using either a threshing frame (hampasan), flail or stick or manual and/or animal treading. Threshed paddy was sun-dried prior to storage and milling. System I served as the control against which the results from the other systems were compared.

Improved technology was used in System IV. Paddy was mechanically threshed with the IRRI-designed axial-flow thresher and subsequently dried in a twin-bed batch dryer.

Systems II and III combined elements of traditional and improved systems in the threshing and drying operations. System II involved manual threshing, but the IRRI-designed batch dryer was used to remove moisture prior to storage and milling. In System III, the IRRI-designed axial-flow thresher was used immediately following harvest, although the paddy was dried under the sun.

Mechanical Thresher and Dryer Specifications. The IRRI-axial flow thresher has a 122 cm-long pegtooth threshing drum inside a full-length oval-shaped concave. The material is loaded onto the tray and fed into the opening between the cylinder and the concave at one end of the machine. The threshing section consists of a rotating pegtooth threshing cylinder enclosed by a round bar grill or wire mesh concave, and a round or hexagonal cover provided with inclined louvers. The louvers assist the axial movement of the material from the feed to the discharge end of the cylinder where it is thrown by the straw paddles. Threshed grain drops through the concave openings where it is either collected or cleaned. A centrifugal blower winnows threshed grain as it falls from the concave. Winnowed grain is conveyed by an auger to a rotary screen which removes residual straw not separated by winnowing (31).

The thresher is mounted on wheels for mobility and it can be hitched to a tractor or a caraboo (water buffalo) for ease of movement inside the field. The machine is a throw-in type with axial movement of material inside the thresher. It has an output capacity of a ton or less per hour of threshed cleaned paddy depending on the condition of the paddy.

The IRRI-designed batch dryer consists of a flat bed with perforated screen floor, a blower, a 3-HP engine or a 2-HP electric motor, ducting, a grain bin and either a kerosene burner or a rice hull furnace to raise temperature of the drying air (32).

The kerosene burner is a gravity flow, pot type consisting of a bowl, baffle, and cover. Fuel from a tank is metered by a manually controlled needle valve. A safety valve actuated by a counterweight vane, stops the fuel flow when the burner stops. In case of rice hulls as alternative energy source, a furnace consisting of a rectangular fire brick chamber with fire brick walls dividing the chambers into combustion and ash settling sections is used instead.

The dryer assembly is connected to the plenum chamber of the bin by a canvas duct for ease of alignment, flexibility and to minimize transmission of vibration from the engine to the bin. The ducting conducts the heated air to the plenum chamber below the perforated screen of the grain bin, which provides space for the grain to be dried.

The blower is 45.7 cm diameter, vane axial type, driven by a 2-HP electric motor or 3-HP gasoline engine. The engine is mounted on the side of the blower assembly with a shroud to recover engine heat. During operation, the blower draws heated air from the burner, or the rice hull furnace, and the engine forces it through the grain via the ducting and plenum chamber. Heated ambient air decreases in relative humidity which increases its moisture absorbing capacity. Heated air passing through the grain mass transfers heat to the grain and absorbs evaporating moisture. This process continues until the grain is dry.

The twin-bed system is similar to the batch dryer with the addition of another bin and duct system. Heated air is alternately directed to each bin for certain time intervals. The bins can be arranged either as a V-shape set-up, end to end or side by side to minimize space. The twin-bed system increases dryer capacity by reducing dryer downtime thus improving the performance and flexibility of its use.

The machine will dry a ton of paddy in 4 to 6 hours depending upon the initial moisture content of the grain.

Implementation of the Field Trials. Depending on the minimum paddy requirement needed to operate a particular system, one or more plots were used in each system treatment. When more than one plot was required, every attempt was made to insure comparable variety and planting dates. For the field trials in Central Luzon, System I required a minimum of 0.5 tons while systems II, III and IV required 1.25 tons each. In the Bicol field trials, the minimum paddy requirement was greater to permit replicated commercial milling tests. Systems I and IV had a minimum paddy requirement of 1.75 tons each while Systems II and III required a minimum of 1.0 ton each.

The area of plot(s) selected for a given system were measured and identified with individual tags. Farm maps for all fields included in the trials were prepared as guides in the planning and scheduling of farm operations.

Replicated crop-cut samples using a two square meter sampler were taken in each post production technology to measure the potential yield at the field level. Actual area yields were obtained by measuring yields after threshing and again following drying. Paddy samples were also taken at each stage of the operational sequence and analyzed in the laboratory to determine changes in quality resulting from the use of a particular treatment. All weight measurements were corrected for moisture content and impurities.

The labor employed for each operation within individual systems, the costs incurred to perform each operation, and the time required to complete an entire sequence of operations were recorded. Rest periods and breaks for snacks and meals were not included in computing total man hours utilized in each operation and/or system. Labor figures, therefore, pertain to the net time utilized in the performance of the different post production tasks. Harvesting in this study covers the time required to cut straw or individual panicles of grain. Handling includes bundling, gathering and stacking of harvested paddy in the field or along the roadside, irrigation dikes, or any other locations in preparation for threshing. Threshing, on the other hand, is defined as separation of the grain from the stalks. Under the traditional system, threshing is considered separately from cleaning or winnowing which involves separation of the grain from immature kernels, chaff, stone and other foreign materials. In the case of mechanical threshing, the paddy is simultaneously threshed and cleaned during the threshing operation. The time required for drying includes handling of threshed paddy in preparation for drying (e.g., bagging, weighing, spreading of threshed paddy on the drying floor, etc.), management of the drying system, and collection and rebagging of dried paddy.

Physical loss and quality deterioration measurements necessary to impute relative benefits and costs for each system were also compiled at each stage of the post-production operations. A more detailed discussion of these loss assessment procedure is presented in subsequent sections of this study.

Analytical Framework

A study of alternative systems in rice post production is a multifaceted problem that encompasses a wide range of operations from time, place and form of harvest to the time, place and form of consumption. Post-production systems include (a) the technical operations of reaping, handling, threshing, cleaning, drying, storage, milling, etc., (b) the associated trading practices and malpractices, (c) the standards, grades and measures of the commodity, (d) the financing-credit system for the rice industry, (e) the physical and institutional infrastructure through which alternative post-production technologies operate, (f) the influence of governmental incentives, regularoty measures, pricing philosophies and policies, and price stabilization strategies on the developmental growth of the industry, (g) the set of cultural, social, organizational, institutional, technical and economic conditions in which the system operates, as well as (h) the attitudes and preferences of the different sectors directly or indirectly involved in the rice post-production system.

Such a study of large, complex systems is facilitated by a method called the "systems approach" where individual elements of the system are analyzed and then these elements are interconnected in such a way as to maximize the performance of the system as a whole ... "The systems view is a holistic one, which implies that isolated study of parts of the system will not be adequate to understand the complete system. This is because the separate parts are linked in an interacting manner. A system implies a complex of factors that are interrelated, it implies interaction among these factors and it implies that a conceptual boundary may be erected around the complex as a limit to its organizational anatomy" (33).

In this study, evaluation of alternative post production technologies was limited to harvesting, handling, threshing, cleaning and drying (Figure 2). Each individual system was assessed within the context of internal and external factors that are likely to influence its performance, including farm size, output and input prices, labor supply and programs, grain quality standards, supportive infrastructures,

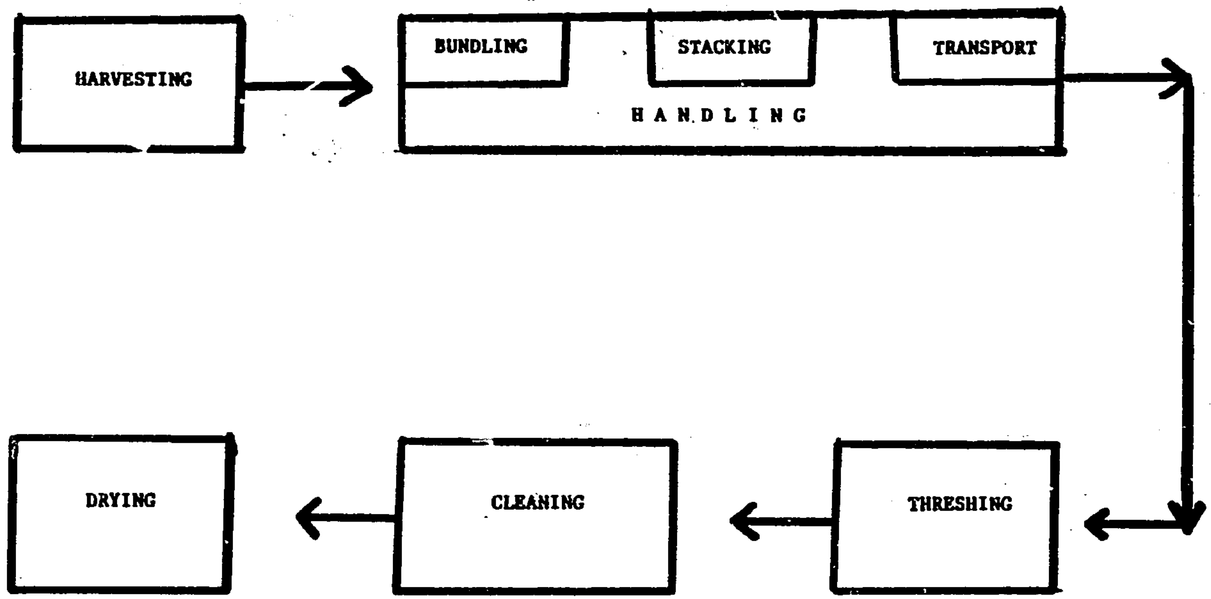


FIGURE 2. RICE POST-PRODUCTION SYSTEMS

institutional arrangements, etc. (Figure 3).

Criteria for Choice of Alternative Technology

Whenever alternatives are available there is always the question of what choice or combination of choices will prove most effective from the point of view of those who are making the decisions.

The choice of technology issue deals with the criteria used in making the choice, the decision process followed and the consequence of the choices made in terms of usage of the different factors of production. The characteristics of alternative systems have to be considered in order to predict and understand the importance of socio-economic and technical variables as determinants to the choice and adoption of a given post production technology (34). There are three characteristics that are particularly important in this regard: a) efficiency, b) factor intensity, and c) complexity.

Efficiency. The issue of efficiency relates to the impact of the technology on costs and yields at the farm level and ultimately on the net farm income. Efficiency is generally measured by changes in costs per unit of output resulting from new and improved inputs or better management of existing factors of production.

There are three measures of efficiency for evaluating decision criteria on investment choices according to Barker (35):

"engineering efficiency - the ratio of physical output to physical input,

private efficiency - the rate of return to private investors, and

social efficiency - the rate of return on investment using shadow prices for factors and products,

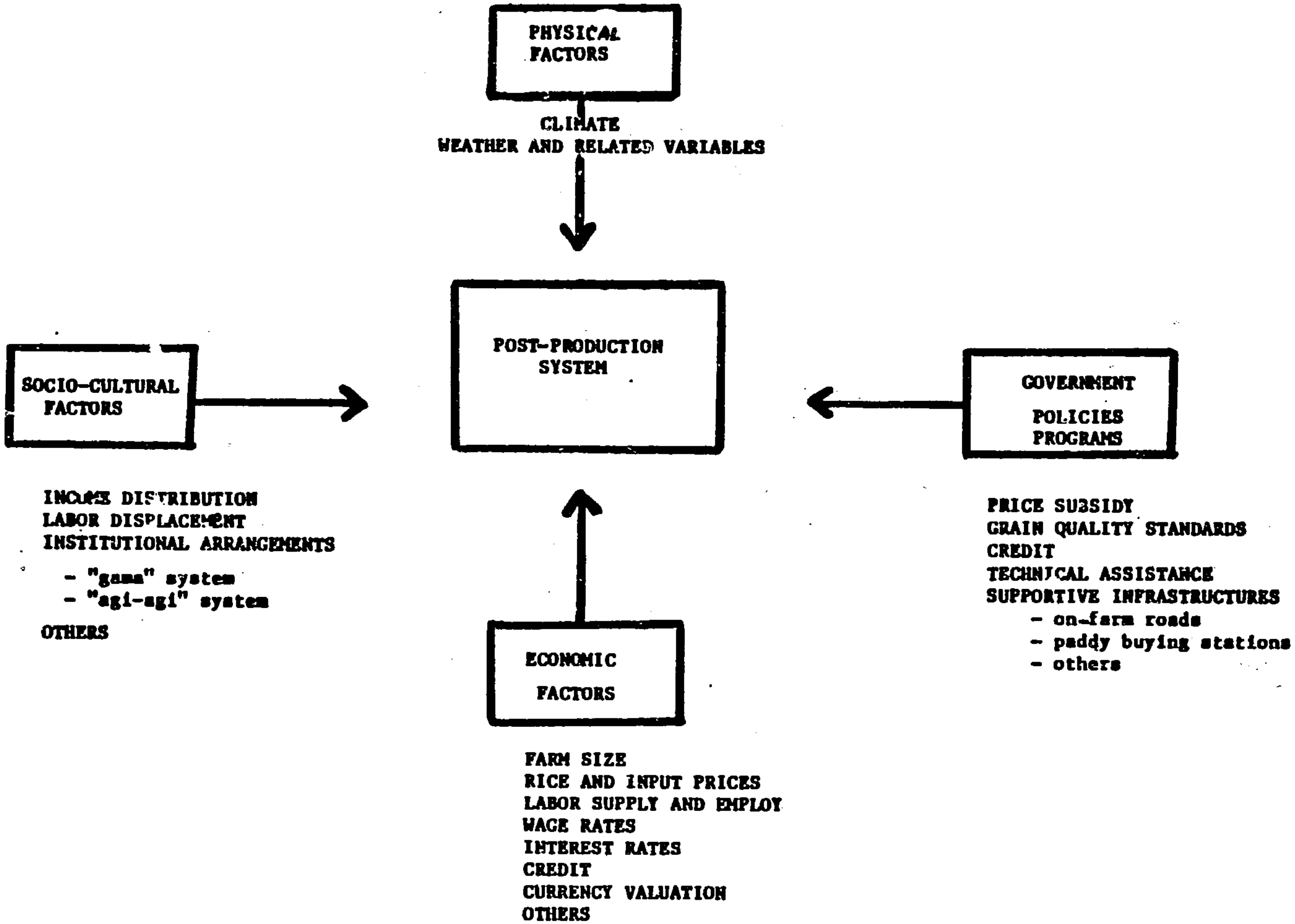


FIGURE 3. ECONOMIC, SOCIO-CULTURAL, PHYSICAL and GOVERNMENT POLICIES AFFECTING THE POST-PRODUCTION SYSTEM

including the spillovers that are not captured by the investors.

"The divergence of social from engineering or private efficiency leads to a misallocation of resources. The conventional view of economic development theory is that market imperfections cause private efficiency to diverge from social efficiency. These market imperfections generally take the form of subsidized interest rates on credit, market wages above the opportunity cost of labor, and overvalued exchange rates, all of which tend to bias private investment toward more capital-intensive techniques. Taxes, subsidies and xternalities may also be a source of bias."

Factor Intensity. This issue relates to the effects of a specific technology on factor shares, i.e., capital-using (labor-saving) - if the ratio of capital to labor employed in the production process rises - or labor-using (capital-saving) - if the capital-labor ratio falls. The significant point is that if factor prices remain constant, technical change which is labor-using increases the relative income share of labor, and capital-using technical change increases the relative share of capital." (36)

Deriving the respective labor (or capital) intensities of each technique, expressed as either the capital-labor ratio or labor-output ratio and determining whether they could be ranked into a continuum ranging from a least labor intensive to a most labor intensive technique would give a rough indication of the possibility of labor-capital substitution in the activites being studied. For the purposes of this study, capital-labor ratio is expressed as value of capital divided by man-hours employed per hectare and per ton of threshed, dried paddy (i.e., two ratios are computed). Capital here refers to fixed investment (i.e., outlay for machine and other capital investment); hence, the capital-labor ratio is given by fixed capital per man-hour employed in the production of a standardized unit of output.

The standardized unit of output used in this study is a ton of threshed, dried paddy to facilitate estimation of annual capacities of different machines used in the operations. Labor is measured in man-hours per ton of threshed, dried paddy. Capital input per ton of paddy was determined by adjusting both investment outlay and fixed repair and maintenance cost for annual capacity and then adding the operating cost per ton of paddy. This required reasonable assumptions on the estimated actual annual capacities of machines included in the analysis (a more detailed discussion of the assumptions is presented in Chapter 4).

Complexity of Concept and Application. Studies focused on the issue of choice and adoption of a given post-production system often neglect the fact that a technology is a stream of practices and inputs which requires adjustment in resource use and management skills and techniques to achieve full benefits accruing therefrom (36). A new technology may represent an improved input or production method that is consistent with existing practices. Conversely, the adoption of a new technology may require acceptance of new biological or technical concepts and/or the ability to follow detailed technical procedures. Both have important implications for adoption and effective utilization of proposed technological change.

The choice of technique in alternative post-production operations is complicated and conditioned by numerous factors. A frequent problem in developing economies like the Philippines is the distortion of relative market prices for labor and capital with respect to relative factor scarcities, resulting in non-optimal use of factors of production. Furthermore, prevailing institutional structures, access to markets and the nature and level of economic incentives facing farmers heavily condition the choice of techniques. The harvesting and threshing phase of post production is particularly sensitive in terms of labor displacement due to widespread practice of paying labor a portion of the harvest after the threshing operation.

In this study, the institutional arrangements prevailing in the study area were examined and their effects on the choice problem assessed. Similarly, other external factors influencing the choice technique, such as quality and price incentives, government policies and programs, etc., were analyzed.

Models Used in the Study

Three analytical models were used to examine efficiency of alternative post-production systems; rate of return on investment, physical loss response functions and quality deterioration response functions.

Economic Feasibility of Technology Investments. A farmer's receptivity to improved post-production technology is conditioned by the availability of capital input. Farmers with sufficient capital are more receptive to change because financially, they can afford to take risks as their resource base is relatively bigger than those farmers who do not have a stable capital base. The choice for a given technique is therefore dependent on whether the capital investments farmers themselves are expected to make will be profitable.

In order to compare the efficiency of alternative post-production techniques, the *Users Guide to Computerized System for Feasible Agribusiness Development* (8) was used in the study. The principal measure of economic soundness used in the feasibility analyses program is the potential annual rate of return on investment based on the time flow of money into and out of a given post-production alternative. The rate of return is calculated by solving for *r* in the formula:

$$I_0 + \frac{I_1}{(1 + r)} + \frac{I_2}{(1 + r)^2} + \ldots\ldots + \frac{I_n}{(1 + r)^n} =$$

$$B_0 + \frac{B_1}{(1 + r)} + \frac{B_2}{(1 + r)^2} + \ldots\ldots + \frac{B_n}{(1 + r)^n}$$

where:

I = net investment each period

B = net benefit each period

n = represents the periods 0, 1, 2, ... n starting with the present

r = interest (discount) rate

Three discounted measures of investment worth were used in this study; net present value (NPV), benefit-cost ratio (B/C) and comparative rate of return (CRR). Net present value is simply the present worth of the cash flow stream. It is computed by finding the difference between the present worth of the benefit stream and the present worth of the investment stream at a specificed annual discount rate. Benefit-cost ratio, on the other hand, gives the discounted benefits per dollar of discounted investments, also at a specified annual discount rate.

Comparative rate of return (CRR) was used to measure the differential rate of return to total capital investment in an alternative post-production system compared to a base case system, which in this study refers to the traditional method of threshing, cleaning and drying commonly practiced in the two study areas. In Central Luzon, the common practice is threshing with the use of the frame (hampasan), cleaning using the winnowing basket (bilao) and drying paddy under the sun. In Bicol, the traditional system consists of threshing paddy with a flail or stick combined with manual treading, cleaning with the aid of wooden winnower (hungkoy) and paddy sun-drying.

In comparative rate of return, I is defined as the schedule of additional capital for the alternative compared to that of the base case, and B, is defined as the schedule of additional net earnings (or savings) for the alternative compared to that of the base case. The internal rate of return (IRR)[2] for the alternative equals the IRR for the base case plus the CRR.

In the analyses of benefits and costs among alternative post-production systems, benefits were measured in terms of output or yield which take into account the marginal benefit (in terms of grains recovered) of improved systems over the traditional ones. Alternatives were analysed which also ascribe increased value of improvements in the quality of the

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[2]The internal rate of return represents the average annual earning power of total capital investment over its expected useful life, regardless of how the enterprise is financed and how the earnings are distributed. It is computed by finding the discount rate which just makes the net present worth of the cash flow equal to zero, i.e., it is the discount rate at which costs equal benefits. In the internal rate of return, I is defined as the schedule of total investment, including replacement of depreciable assets as needed, and B is the schedule of net earnings before depreciation, interest payments and income tax.

grains for systems using mechanical dryers on the assumption that specified price margins are given for good quality grain.

On the capital outlay side, the acquisition price of each piece of capital investment in a given system or technique was used. For the mechanical threshers and dryers, the commercial price was considered in the analyses instead of the project price to simulate the actual outlay farmers would have if they purchase the equipment in the commercial market. Fixed costs consist of repairs and maintenance and related expense.

Operating costs include the value of fuel, oil and grease and the wages of hired labor. A more detailed discussion of the assumptions used in the analyses is presented in Chapter 4.

Loss Response Functions. The loss response functions were estimated using the General Linear Models (GLM) of the Statistical Analysis Systems (SAS). The variables considered in the models were selected from a whole list of explanatory variables based on economic theory, logic and statistical relationships. These include those variables that showed significant influence on the variability of physical and quality losses using the Central Luzon data which include: (a) post-production input variables, (b) inferior quality characteristics of paddy and milled rice, (c) varietal characteristics, and (d) interactions between pairs of independent variables. In the analysis, the data from the two regions were combined to increase the size of sample to 295 observations (145 from Central Luzon and 150 from the Bicol Regions). Two post-production tasks were considered in the assessment of physical and quality losses; threshing and drying. The choice was limited to these two tasks because preliminary results from Central Luzon indicated that among the different tasks, it was in threshing and drying operations that the influence of the different paddy and milled rice characteristics on physical losses and rice recovery was more evident. The loss response models were grouped into two general categories: (1) physical loss response functions, and (2) quality deterioration response functions.

<u>(1) Physical Loss Response Models</u>. In the physical loss response models, two dependent variables were considered; threshing loss (THLOSS) and total milling recovery (MILLREC).

Threshing loss is the difference between the potential harvest yield per hectare obtained from crop-cutting and the actual amount of paddy recovered after threshing and cleaning including the amount of grains recovered from gleanings, i.e.,

$$\text{Loss per hectare (Y)} = \frac{\text{harvest yield } (X_3) - \text{threshing yield } (X_1)}{\text{Plot size } (X_2)} \times 10{,}000$$

<u>where</u>: harvest yield (X_3) = potential yield based on crop cut samples corrected for moisture content and impurities

threshing yield (X_1) = weight of paddy recovered after threshing operation corrected for moisture content and impurities

plot size = area of plot included in the field trials.

Percent total milling recovery, on the other hand, is a measure of milling yield rather than of milled rice obtained (see Appendix B). It is computed as:

$$\text{\% Milling Recovery} = \frac{\text{wt. of milled rice obtained}}{\text{wt. of paddy sample used in hulling}} \times 100$$

<u>(2) Quality Deterioration Response Functions</u>. The two measures considered as dependent variables in the quality deterioration response models were percent head rice recovery and numerical grade of milled rice as defined in the Philippines Standard Grade Requirements for Milled Rice (Appendix E). Head rice recovery was selected as one of the dependent variables since from the laboratory analysis of paddy samples taken during the field trials, three measures of milled rice quality were considered: (1) percentage head rice, (2) percentage broken kernels, and (3) percentage brewers rice or "binlid" (Appendix C). The higher the percentage head rice, and conversely, the lower the percentage of brokens and binlid, the higher the quality and greater the value of a given quantity of milled rice. Because the percentage of brewers' rice was very small for all samples, the correlation between percentage head rice and percentage brokens is nearly -1.0, so that one measure acts as proxy for the other (see Tables 4 and 5). For this reason, percent head rice was used as the dependent variable for quality of milled rice in the regression analysis reported in this section.

Grade of milled rice (GRADE) in this study refers to the overall quality of the grain in terms of percent head rice, brokens, brewers' rice or "binlid", damaged and chalky kernels, presence of other varieties, red rice and percent foreign matter, i.e.,

GRADE = HDRICE + BRKENS + binlid + damaged kernels + chalky kernels + other varieties + red rice + foreign materials

Using the Philippine Standard Specifications of Grade for Milled Rice (Appendix E), three grade classifications were used in this analysis:

Grade 1 = when total percentage points are less than or equal 110

Grade 2 = when the total percentage points are greater than 110 but is less than or equal 125

Grade 3 = when the total percentage points are greater than 125

Since the amount of head rice, brokens and brewers' rice sums up to 100 percent, the residual above 100 reflects the total percentage points of the inferior quality characteristics of milled rice. Therefore, a Grade of 1 means best quality rice and a Grade 3, the poorest.

The general form of the equation and the variables used in the physical and quality deterioration loss response functions is expressed as:

(2-1) $Y = a + b_1X_1 + b_2X_2 + \ldots\ldots\ldots\ldots + b_n X_n$

<u>where</u>:

Y = dependent variables which include:

(a) THLOSS = amount of threshing loss per hectare (kg/ha)

(b) MILLREC = percent total milling recovery

(c) HDRICE = percent head rice recovery

(d) GRADE = numerical grade of milled rice

a = intercept

X's = explanatory variables which include:

(a) post-production input variables measured in observed values per standardized unit of output

(b) Inferior quality characteristics measured as continuous variables expressed as percentage of total paddy and milled rice weight

(c) Varietal characteristics measured by IRRI standard scales (see Appendix B for more detail)

(d) Environmental characteristics measured as dummy variables

(e) Interaction between pairs of independent variables

The data on yield, labor requirement and elapsed time by post-production tasks were actual measurements recorded during the field trials. For the different varietal characteristics (e.g. maturity, lodging, shattering, etc.), scales were based on the IRRI Standard Evaluation Systems for Rice prepared by the International Rice Research Testing Program (Appendix B).

The qualitative characteristics of paddy and milled rice were obtained from the results of the laboratory analysis of paddy samples taken at each stage of the post-production sequence of operations (see Appendix D for details on how each of the figures were computed).

A more detailed discussion of the different explanatory variables used in the General Linear Models is presented in Chapter 3. For both physical and quality deterioration loss response models, regression analysis was done for threshing and drying operations. Combined physical and quality deterioration variables were considered in the analysis to test for possible interrelationships as these factors affect post-production losses and quality characteristics of paddy and milled rice.

CHAPTER III

PHYSICAL LOSSES AND QUALITY DETERIORATION IN RICE POST-PRODUCTION

Loss Assessment Methodology Used in the Field Trials

This section presents the general considerations and procedures followed during the implementation of the field trials to assess physical losses of and quality deterioration in paddy and milled rice among alternative post-production systems. Problems encountered in the assessment of losses are discussed as they relate to the accuracy and representativeness of the results.

Selection of Plots and Size Requirements

In the selection of field plots for alternative post-production systems, care was taken that conditions in these plots were comparable in terms of variety planted, date of harvest, soil and water condition and production practices. Plots selected had to be adjacent or in one contiguous area for comparability and ease in implementation.

With regard to the size of plot, one major consideration was the minimum paddy requirement (i.e., the smallest volume of paddy required in the normal operation of a particular technology being assessed) of a given system. The size of plot initially selected at the point of harvest had to be of sufficient size to provide sufficient volume of paddy required for each succeeding operation. Therefore, depending on the minimum paddy requirement, one or more plots were used in each system treatment.

For the field trials in Central Luzon the traditional system required a minimum of 0.5 tons while the mechanized system or a combination of traditional and mechanical required 1.25 tons. In the Bicol field trials, the minimum paddy requirement was greater to permit replicated commercial milling tests. The traditional and fully mechanized systems required a minimum of 1.75 tons each while systems with combined traditional and mechanized techniques ahd a minimum of 1.0 tons.

After the plots were selected, the areas were measured and marked. In the measurement of total plot size, levees and bunds not planted to rice were excluded to avoid overestimating the actual land area planted to paddy. Farm maps of field plots included in the loss assessment exercise were prepared to serve as guides in the planning of each farm operation.

Calendar of Operation

Timeliness is a basic consideration in loss assessment studies because any delay in planning or implementation greatly affects the magnitude and quality of results. A calendar of operation for paddy was kept for each farmer cooperator to plan and monitor the different farm operations. Harvest dates (as estimated by the farmer) were recorded in the individual record so that all the needed preliminary steps and preparation such as crop cutting were accomplished ahead of time. And since dates of harvest can be moved either earlier or later than the set time due to environmental and other uncontrolled factors, field assessors had to check regularly with the farmer for any changes during the "waiting period." In spite of this, there were still instances when the team was not notified on time about changes in the date of harvest thus resulting incomplete data.

Problems were also encountered in the timely use of the mechanical threshers by farmer cooperators. The axial-flow thresher has been very popular among the members of the farmer associations, so that cooperators, who according to project agreement were to be given priority in the use of the machine, actually had to wait for their turn (delays averaged from 2 to 4 days). In addition to poor scheduling, lack of funds to operate and maintain equipment further complicated the problem. There were times when fuel and oil were purchased only when needed, prompting the field staff to make cash advances so as not to jeopardize timely execution of field trials.

In the drying operation, immediate need for cash prompted some farmers to sell their paddy immediately after threshing without waiting for full completion of data collection. In some cases farmers were only willing to dry a portion of their crop thus affecting continuity of the exercise from harvesting to drying and milling. Re-luctance of farmers to use batch dryers also posed some problems.

Assessment of Physical Loss in Alternative Post-Production Operations

To obtain a more meaningful and effective result, every effort was made to conduct the field trials in the "natural environment" without creating any artificial condition or disrupting the farmers traditional post-production practices. The farmers were given a free hand in the performance of the different post-production tasks the way they ordinarily do and it was only when mechanical threshers and dryers were involved that the field staff supervised the whole oepration.

In the assessment of quantity losses, all yield and weight measurements were corrected for moisture content and impurities.

Potential and Actual Yields

To measure potential yield of plots considered for a given system, crop-cut samples were taken from fields declared ready for harvest by the farmer cooperator. Crop-cut sampling was completed by the project team before harvesters were allowed in the field. The two square meter sampling frame was used in the field trials with the number of crop-cut samples dependent on the total area plots under consideration. Actual area yields were obtained by measuring output after threshing, cleaning, and again following drying.

Harvesting Loss

The different loss components assessed during harvesting include:

(a) Shattering loss, which is the premature shedding or separation of sound and mature grains from the panicle. This is caused by wind, birds, varietal characteristics, maturity, handling operations, etc.

(b) Lodging loss, which includes sound and mature grains that remain intact with the plants that are drooping or lying flat on the ground due to varietal characteristics or environmental conditions.

(c) Standing crop loss, which corresponds to the sound, mature grains left harvested on the standing plants during harvesting operation as a result of oversight, carelessness or haste in accomplishing the task. This is very common for border line plants where tall grasses or weeds grow side by side with the rice plant.

To assess harvesting loss, a 2 sq m steel sampling frame was used. Depending on the total area of a given plot, the sampler was used two or more times within the total field where harvesting had just been completed. All grains within the area of the frame that had fallen on the ground or which were left intact in standing crops as well as lodged plants were manually picked and weighed. Efficiency of this exercise was hampered by recurring rains resulting in flooded fields especially during the wet season. Data gathered were limited, correspondingly.

Stacking Loss

To measure stacking losses, farmers were provided with plastic or canvas sheets to be used as underlay for the harvested paddy while waiting for the threshing operation. The grains remaining on the sheet after bundles were taken and carried to the threshing site were considered as stacking loss.

Threshing Loss

The different loss components considered during threshing include:

(a) Loose straw and chaff loss, which includes the sound and mature grains that were mixed with the straw or chaff or and other impurities during the threshing/cleaning operations. In the case of mechanical threshers, this is usually referred to as blower loss.

(b) Scattered loss, which is composed of sound and mature grains scattered on the gound after the threshing and/or cleaning operations.

(c) Unseparated grain loss, which include the sound and mature grains remaining on or in the straw after completion of the threshing operation. This is usually referred to as separation loss in mechanical threshing.

In the case of traditional methods of threshing using either the flail and/or stick or the threshing frame (hampasan), canvas or plastic sheets were spread near or on the threshing floor to catch all possible grains lost or scattered during the operation. After threshing, all the sound and mature grains scattered on the sheet or outside of it away from the heap of threshed paddy were manually picked, weighed and moisture content recorded. This recovered grain was recorded as scattered loss if the farmer does not ordinarily try to recover it. If he does, then it was not considered as a loss.

When local people are allowed to glean or re-thresh the straw, the grains recovered by these gleaners (mambabarog) were considered part of the threshing loss. Ocassionally, field staff would check further the threshed straw worked by gleaners and recover whatever sound grain that may still be present on the straw. Grains recovered by the staff were added to the total threshing loss figure.

With the axial-flow thresher, canvas and plastic sheets were also used to recover and assess paddy discharged onto the ground. Sheets were spread near the feeding and bagging area to recover any scattered losses. Separate sheets were used to catch the blower output. To determine separation loss, the threshed straw was manually re-threshed or mechanically recycled in the thresher (depending on the volume of straw involved) to recover sound and mature grains remaining on or in the stalks. Sound and mature grains mixed with the chaff or broken straw coming from the blower/screen outlet were collected and recorded as blower loss. Scattered grains on or outside of the sheets at the feeding and bagging area not ordinarily recovered by the farmer were picked and recorded as scattered loss.

Cleaning Loss

Assessment of grain lost during cleaning or winnowing operation was initiated only in the traditional system using either the winnowing basket (bilao) or wooden winnower (hungkoy). Loss figures under this operation consist of the scattered sound and mature grains mixed with the chaff or straw that were blown away during cleaning and were not normally recovered by farmers. The use of canvas or plastic sheets facilitated recovery of scattered grains.

Drying Loss

Assessment of drying loss was based upon the simple principle of weigh-in and weight-out. Initial and final moisture content and weight measurements were taken from each system before and after drying.

In this study, drying loss pertains to handling loss which is the removal of the grain or portions of grain from the drying system due to spillage, improper or careless handling, pilferage, consumption by birds, rodents, or chickens, blown by the wind either from natural causes or by passing vehicles in case of paddy drying along or beside the road or highway.

To arrive at the handling loss figure, the weights obtained before and after drying were first adjusted to percent purity. Thus, what remained is the weight of paddy and the amount of moisture present in the grain. The moisture content, which is on a wet weight basis, taken before and after drying was converted into dry weight basis using the conversion scale of Brooker, Bakker-Arkema and Hall (46).

Then the following computational procedure was used to arrive at percent drying (handling) loss:

(1) MC_1 (wb) x W_1 = A

(2) $W_1 - W_2$ = B

(3) W_1 - A = DM_1

(4) MC_1 (db) - MC_2 (db) * DM_1 = C

(5) B - C = D

(6) D ÷ W_1 *100=E

<u>where</u>:

MC_1 (wb) = initial moisture content, wet basis

W_1 = initial weight of paddy before drying

W_2 = final weight of paddy after drying

MC_1 (db) = initial moisture content, dry basis

MC_2 (db) = final moisture content, dry basis

A = kilograms of water present

B = weight lost during drying

C = amount of evaporated water

D = handling loss in kilograms

E = handling loss in percent

DM_1 = amount of dry matter

Assessment of Quality Deterioration in Alternative Post-Production Operations

To evaluate the impact of alternative post-production technologies on the quality of paddy and milled rice, 750 gram paddy samples were taken at each stage of the post-production sequence of operations, (a) before harvest, (b) after harvest, (c) after threshing, (d) after cleaning, (e) before drying, and (f) after drying. These samples were dried individually to 14 percent moisture content in the sample laboratory dryers brought to the study area. Dried samples were then placed in individual plastic bags, labelled, sealed and delivered to the National Foods Authority laboratory for analysis. For the Central Luzon trials, paddy samples were sent to the NFA laboratory in Manila while in Bicol, the NFA laboratory facilities in Ligao, Albay was used.

In the quality assessment, samples collected during the field trials were analyzed against the criteria prescribed by the Philippine Grades and Standards for paddy and milled rice. These criteria include:

Moisture Content, the amount of water held by the grain. Moisture content is usually expressed as a mass of water per unit mass of wet grain (wet weight basis) or mass of water per unit mass of dry grains (dry weight basis). In trade and industry, moisture content wet weight basis is usually used, and was used in this study.

Foreign Material, all impurities other than rice which includes weed seeds, straw, chaff, stalks, stone, sand, dirt, etc.

Other Varieties, rice kernels of different variety other than the one being analyzed.

Cracked Kernels, kernels that have seed coats cracked by mechanical means or by drying too rapidly with excessive heat.

Damaged Kernels, kernels or pieces of kernels of rice which are distinctly discolored or damaged by water, insects, heat or any other means.

Fermented Kernels, yellowish milled rice due to fermentation or heat.

Chalky and Immature Kernels, kernels which are undeveloped, shrivelled and with 50 percent or more white portion. Depending on the location of chalk on the kernel, the chalky spots may be referred to as "white belly", "white core" or "white back".

Red Rice, rice with any degree of redness. The red seed coat (pericarp) is usually in the form of a firmly adhering bran.

Head Rice, whole kernels and those not less than 3/4 of whole kernel size.

Brokens, milled rice smaller than head rice but larger than brewers' rice or "binlid".

Brewers' Rice or "Binlid", portions of a kernel which will pass through a 4/64 sieve (1.587 mm).

The procedure for the analysis of the samples obtained from each post-production operation is illustrated in a flow diagram presented in Appendix C.

Results of the Field Trials

Physical Loss

A comparison of physical losses per hectare among alternative post-production systems showed that the mechanical thresher and dryer combination incurred lower losses than the traditional system (Table 2). Although these figures were taken from very limited samples due to the problems encountered during the implementation of the field trials, the results still indicate the potential of mechanized systems in reducing these loss.

In interpreting the results of these physical losses, one should bear in mind that the importance of the loss varies depending on how the farmer-owner or cultivator views them. The figures can be lower or higher depending on whether farmers normally try to recover the "loss" or whether they deliberately ignore it in order to help landless laborers and small farmers share a part of the produce through the gleanings they are allowed to take freely during the harvest season.

Another measure of physical loss considered in this study is the threshing loss (THLOSS) which is the difference between the harvest yield per hectare and the threshing yield per hectare. Harvest yield in this analysis was based on the potential yield obtained from crop-cut samples taken from plots included in the loss exercise. Threshing yield, on the other hand, is the total amount of paddy recovered after the threshing and cleaning operation including the amount of gleanings or loss recovered. All the yield and weight measurements were corrected for percent moisture content and purity.

Table 2. Average physical losses among alternative post production systems by region, Philippines, 1975-1977.

Post production System	Central Luzon	Bicol Region
	Percent Loss	
Axial-Flow Thresher	1.10	0.48
Threshing Frame	2.40	1.56
Flail and/or stick	-	1.20
Winnowing Basket (bilao)	1.14	-
Wooden Winnower (hungkoy)	-	1.05
Batch Dryer	0.38	0.42
Sun Dryer	1.16	1.24

Amount of threshing loss per hectare incurred in subsequent post production operations were ranked and tested at five percent level of significance using Duncan's Multiple Range Test in the Statistical Analysis System (SAS) program. Between regions, although Bicol exhibited a higher THLOSS per hectare over that of Central Luzon, the difference was not statistically significant. Therefore, in subsequent analysis, observations from the two regions were combined to test for significant differences in threshing loss among post-production tasks.

Results of the test showed significant reduction in THLOSS per hectare when paddy was harvested on time and when mechanical threshers were used in the threshing and cleaning operation (Table 3).

In paddy handling which includes bundling, hauling and stacking, lthough timely performance of the task resulted in a lower THLOSS over that of delayed handling, the difference was not statistically significant.

Quality Deterioration

There was much variability in observations for different post-production operations between systems due largely to the failure to control some of the variables that affected the efficient performance of the different systems during the implementation of the field trials. Rain after harvest but before threshing often damaged the grain that was stacked or bundled in the field. Timeliness in the use of mechanical threshers likewise affected the results of the trials. Subsequent drying operations could do little to rectify these effects.

Results of the quality deterioration analysis indicate only slight

Table 3. Means for threshing loss (THLOSS) by alternative groupings in post-production operations, Philippines, 1975-1977.

Item	THLOSS[1] (kg/ha)
Harvesting	
Timely harvest	622.98 A
Delayed harvest	849.22 B
Handling (bundle, haul, stack)	
Timely handling	710.85 A
Delayed handling	820.98 A
Threshing	
Axial-flow thresher	626.13 A
Threshing frame/flail or stick	856.21 B
Cleaning	
Axial-flow thresher	639.69 A
Winnowing basket/wooden winnower	848.53 B
Comparative THLOSS by region	
Central Luzon	694.77 A
Bicol Region	764.20 A

[1]Threshing loss (THLOSS) is the difference between potential harvest yield per hectare and the yield obtained after the paddy is threshed and cleaned. Using Duncan Multiple Range Test (DMRT) at 5 percent level of significance, treatment means with the same letter are not significantly different from each other.

advantage of the fully mechanized system[6] over the traditional practice[7] in terms of cracked and damaged kernels in either region (Table 4). The same is true in terms of total milling recovery. However, the mechanized system exhibited higher percent head rice recovery than the traditional system, this in spite of the delays during the threshing operation.

The Duncan Multiple Range Test of the SAS program was used to test whether there were significant differences in percent head rice and percent broken kernels among subsequent post production tasks, this time using the revised sub-grouping by specific machine or equipment used. Results of the test showed that timely harvest had significantly higher percent head rice and significantly lower broken kernels than delayed harvest (Table 5). In handling operations, no significant difference was observed between timely and delayed handling although the former exhibited higher performance.

Among alternative threshing techniques, the threshing frame (hampasan) and the axial-flow thresher exhibited significantly higher head rice recovery and significantly lower broken kernel content than the flail and/or stick. Between the threshing frame and the axial-flow, the former performed slightly better than the latter and this can be partly attributed to the practice of threshing even high moisture paddy when the mechanical threshers were used, resulting in a lower percentage

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[6]In both regions, fully mechanized system involved the use of mechanical threshers and dryers.

[7]Traditional system in Central Luzon refers to the use of threshing frame, winnowing basket and sun drying. In Bicol, traditional system consist of threshing frame or the use of flail and/or stick combined with manual treading, cleaning with the wooden winnower and paddy sun drying.

Table 4. Mean values for selected quality characteristics of paddy samples between traditional and fully mechanized post-production systems by region, Philippines, 1975-77.

Criteria	Central Luzon		Bicol Region	
	Traditional[1]	Mechanized[2]	Traditional[1]	Mechanized[2]
		(percent)		
Cracked Kernels	3.15	2.71	4.12	3.36
Dāmaged Kernels	0.85	0.66	1.39	1.66
Milling Recovery	66.32	66.75	67.98	68.62
Head Rice	78.13	82.93	79.45	84.09
Brokens	20.97	16.54	19.07	14.50

[1]Traditional system in Central Luzon refers to the use of threshing frame, winnowing basket, and sun drying. In Bicol, the traditional system consist of threshing using flail and/or stick or the frame, cleaning with wooden winnower and paddy sun drying.

[2]For both regions, mechanized system involves the use of mechanical threshers and dryers.

of head rice and more broken kernels. With traditional systems, only sufficiently dried paddy can be threshed and cleaned.

Finally in drying, timely use of the batch dryer resulted in significantly higher percent recovery in head rice than delayed batch drying and timely and delayed sun drying. The batch dryer also yielded significantly less brokens than sun drying (Table 5).

Duncan Multiple Range Test was also used to determine the influence of timeliness in handling and methods of threshing and drying on the different inferior quality characteristics of paddy and milled rice such as impurity, cracked, fermented, chalky and damaged kernels.

There were significantly lower percentages of cracked and fermented kernels in timely handling than that of delayed handling. Timely handling operations also exhibited relatively lower amounts of chalky and damaged kernels although the difference observed was not statistically significant. In terms of impurity, timely handling showed a greater percentage than delayed operations, however, the difference was not statistically significant (Table 6).

Among the different methods of threshing, the mechanical thresher (as well as the flail and/or stick) exhibited significantly less foreign matter and impurities than the threshing frame. This in spite of the fact that most farmers use the machine even with high moisture paddy. However, this practice partly contributed to a higher percentage of fermented kernels for the axial-flow thresher than for the traditional threshing frame. In terms of cracked, chalky and damaged kernels, threshing frame performed better than the axial-flow although the difference observed was not statistically significant (Table 7).

The alternative drying techniques did not show significant

Table 5. Average head rice recovery and broken kernels by alternative post-production operations, Philippines, 1975-1977.

	Head Rice	Brokens
	percent[1]	
Harvesting		
Timely harvest	83.39 A	15.63 A
Delayed harvest	72.67 B	25.57 B
Handling		
Timely handling	84.59 A	14.69 A
Delayed handling	77.78 A	21.36 A
Threshing		
Threshing frame	81.87 A	17.02 A
Axial-flow thresher	78.41 A	20.18 A
Flail/stick	70.44 B	27.33 B
Drying		
Timely batch drying	82.82 A	15.87 A
Delayed/staggered batch drying	77.02 B	21.63 B
Timely sun drying	76.93 B	21.66 B
Delayed sun drying	75.81 B	22.86 B

[1]Using Duncan Multiple Range Test (DMRT) at 5 percent level of significance, treatment means with the same letter are not significantly different from each other.

Table 6. Mean values for inferior quality characteristics of paddy samples by timeliness in handling, Philippines, 1975-77.

Item	Mean Values[1] (percent)
<u>Impurity</u>	
Timely handling	7.7000 A
Delayed handling	6.4050 A
<u>Cracked kernels</u>	
Timely handling	6.0744 A
Delayed handling	9.0605 B
<u>Fermented kernels</u>	
Timely handling	0.2322 A
Delayed handling	1.8872 B
<u>Chalky kernels</u>	
Timely handling	8.2400 A
Delayed handling	8.4018 A
<u>Damaged kernels</u>	
Timely handling	1.0389 A
Delayed handling	1.3350 A

[1]Using Duncan Multiple Range Test (DMRT) at 5 percent level of significance, treatment means with the same letter are not significantly different from each other.

Table 7. Mean values for inferior quality characteristics of paddy samples by methods of threshing, Philippines, 1975-77.

Item	Mean Values[1] (percent)
Impurity	
Axial-flow Thresher	3.9199 A
Flail and/or stick	4.6772 A
Threshing Frame	5.7734 B
Cracked kernels	
Threshing frame	2.6665 A
Axial-flow thresher	4.5641 A
Flail and/or stick	7.459 B
Fermented kernels	
Threshing frame	1.2642 A
Flail and/or stick	1.8945 B
Axial-flow thresher	1.9540 B
Chalky kernels	
Flail and/or stick	5.4765 A
Threshing frame	7.3452 B
Axial-flow thresher	7.5005 B
Damaged kernels	
Threshing frame	0.9758 A
Flail and/or stick	1.3363 A
Axial-flow thresher	1.5560 A

[1]Using Duncan Multiple Range Test (DMRT) at 5 percent level of significance, treatment means of the same letter are not significantly different from each other.

differences in the amount of impurity, cracked, fermented, chalky and damaged kernels, partly because of the limited size of sample by sub-categories. However, among the four drying systems, timely batch drying showed the best performance in terms of relative percentage values followed by timely sun drying. Except in terms of cracked kernels, delayed batch drying exhibited the higher percentage values of inferior quality characteristics of paddy and milled rice than did delayed sun drying. This can be attributed to the farmer's practice of utilizing mechanical dryers only when sun drying is rendered impossible and batch drying is the only recourse to save the grain (Table 8).

Loss Response Relationships Based on Combined Trials

From the results of preliminary analyses using the Central Luzon data, revised loss response functions were formulated and tested to improve the model. The four post-production systems considered in the field trials were further segregated for each specific post-production task according to timeliness in the performance of the operation as well as machines or tools used (see discussion in Chapter 1).

Moreover, since no significant differences were observed in the THLOSS by region, observations from the two areas were combined to increase sample size.

The loss response functions were estimated using the General Linear Models (GLM) of the Statistical Analysis Systems (SAS). In the models, only those variables shown to have significant influence on the variability of THLOSS such as labor inputs and elapsed time were considered. In addition, alternative post-production tasks were considered as explanatory variables. The presence of interactions between pairs of

Table 8. Mean values for inferior quality characteristics of paddy samples by methods of drying, Philippines, 1975-77.

Impurity	
Timely batch drying	2.1400 A
Delayed " "	4.4535 A
Timely sun "	3.1016 A
Delayed " "	3.1840 A
Cracked kernels	
Timely batch drying	2.6958 A
Delayed " "	5.7130 A
Timely sun "	5.6749 A
Delayed " "	9.8773 A
Fermented kernels	
Timely batch drying	1.7373 A
Delayed " "	2.7894 A
Timely sun "	2.1766 A
Delayed " "	2.5887 A
Chalky kernels	
Timely batch drying	6.7187 A
Delayed " "	8.4929 A
Timely sun "	5.7727 A
Delayed " "	7.1516 A
Damaged kernels	
Timely batch drying	1.2500 A
Delayed " "	1.6617 A
Timely sun "	1.2694 A
Delayed " "	1.4660 A

[1]Using Duncan Multiple Range Test (DMRT) at 5 percent level of significance, treatment means of the same letter are not significantly different from each other.

independent variables also was tested in the models.

In the analyses, a combination of quantity and quality-oriented variables were considered in the model. In the assessment of physical and quality losses two post-production tasks were considered, threshing and drying. Four measures were used as dependent variables in each model; paddy grade, percent head rice, total milling recovery and threshing loss.

The General Linear Models using SAS format were of the forms:

(3-1) THLOSS = f (PLTSIZE, MDHVHA, ETHV, ETTH, thresh, clean, region, ETHVTH, brokens, impurity, THRHBROK, THRHIMPU)

(3-2) HDRICE (Threshing) - f (crackK, damageK, chalkyK, fermentK, MC, harvest, handle, thresh, region, MDHVHA, MDTHHA, ETHV, HARVMC, THRHMC, THRHDAM, MDETHV)

(3-3) HDRICE (Drying) = f (chalkyK, impurity, crackK, fermentK, damageK, harvest, handle, thresh, clean, dry, region, MDHVHA, MDDRHA, ETHV, ETDR, MDETHV, MDETDR, DRYFERK, ETTHFERK, DRYDAM, CLENIMPU, THRHCRAK, DRYCRAK)

(3-4) MILLREC (Threshing) = f (MC, chalkyK, impurity, crackK, fermentK, damageK, othervar, harvest, thresh, MDTHHA, ETTH, MDETTH, ETTHFERK, CLENIMPU, THRHCRAK, HANDCRAK, THRHBROK, MCRACK, THRHMC)

(3-5) MILLREC (drying) = f (MC, chalkyK, impurity, crackK, fermentK, damageK, othervar, harvest, thresh, MDTHHA, ETTH, MDETTH, ETTHFERK, CLENIMPU, THRHCRAK, THRHBROK, MCRACK, THRHMC)

(3-6) GRADE (Threshing) = f (MC, fermentK, handle, clean, region, MDHVHA, ETHV, ETTH, maturity, ETHVTH, MDETHV, HANDMC, HANDFERK, ETTHFERK)

(3-7) GRADE (Drying) = f (MC, crackK, fermentK, harvest, handle, thresh, dry, region, MDHVHA, MDTHHA, MDDRHA, ETHV, ETDR, lodge, maturity, MCRACK, MCFRMENT, ETHVTH, ETHVDR, MDETHV, MDETTH, HARVMC, HARVFERK, ETHVFERK, DRYFERK, THRHCRAK, HADCRAK, DRYCRAK)

where:

Dependent Variables considered in the models include:

THLOSS = amount of threshing loss per hectare in kg

MILLREC = total milling recovery expressed in percent

HDRICE = percentage of head rice in milled product

GRADE = numerical market grade of milled rice

Inferior Quality Characteristics include:

MC = moisture content in percent

CrackK = percent cracked kernels

Othervar = percent other varieties of rice mixed with the grain under consideration

FermentK = percent fermented kernels

DamageK = percent damage kernels

ChalkyK = percent chalky kernels

Redrice = percent red rice

Impurity = sum of percent chaff and weed seeds

Brokens = percentage of broken kernels in milled product

Definitions of these paddy and milled rice characteristics are discussed in earlier sections of this Chapter.

Post-Production Input Variables include:

PLTSIZE = area of plot included in the trials in sq m

MDHVHA = man hours in harvesting per hectare

MDTHHA = man hours in threshing per hectare

MDDRHA = man hours in drying per hectare

ETHV = hours of elapsed time from harvesting to threshing

ETTH = " " " " " threshing to drying

ETDR = " " " " " harvesting to drying

Harvest = timeliness in harvesting

Thresh = alternative methods of threshing (mechanized vs. traditional)

Handle = timeliness in handling

Clean = alternative methods of cleaning (traditional vs. mechanical)

Dry = timeliness and method of drying

Region = Central Luzon or Bicol Region

Varietal Characteristics include:

Maturity = standard no. of days from seeding to grain ripening by variety

Lodge = increasing index of tendency of variety to lie flat on the ground at maturity

Interactions between two Independent Variables include:

ETHVDR = delay in harvest by delay in drying

ETHVTH = delay in harvest by delay in threshing

MDETTH = man hours threshing by delay in threshing

MDETHV = man hours harvesting by delay in harvesting

MDETDR = man hours drying by delay in drying

MCRACK = moisture by cracked kernels

MCFRMENT = moisture by fermented kernels

MCDAMAGE = moisture by damaged kernels

CLENIMPU = clean by impurities

OVARED = other varieties by red rice

DAMCHALK = damaged kernels by chalky kernels

ETTHFERK = elapsed time from threshing to drying by fermented kernels

ETHVFERK = elapsed time from harvesting to threshing fermented kernels

DRYFERK = dry by fermented kernels

THRHCRAK = thresh by cracked kernels

HANDCRAK = handle by cracked kernels

DRYCRAK = dry by cracked kernels

DRYDAM = dry by damage kernels

HARVMC = harvest by moisture content

HARVFERK = harvest by fermented kernels

THRHMC = thresh by moisture content

THRHDAM = thresh by damaged kernels

HANDMC = handle by moisture content

HANDFERK = handle by fermented kernels

THRHBROK = thresh by broken kernels

THRHIMPU = thresh by impurities

In the graphical presentation of the results of the models (Figure 4 to 9), losses in percent head rice, total milling recovery as well as grade of milled rice were plotted against two values; (a) scaled value of alternative post-production tasks on the upper horizontal axis, and

(b) percentage change in the quality variables on the lower horizontal axis. To distinguish between the scaled values and percentage changes, bold broken lines are used to represent the former and solid lines are used in the latter. Other explanatory variables such as man hours required in each post-production task, elapsed time between operations and interaction terms between two independent variables are not included in the graphs since these variables are expressed in different units.

The scales used for the different post-production tasks follow the revised sub-grouping as defined. Since the scale was set up in ascending order according to degree of loss, the scale values for threshing and cleaning had to be mulitplied by -1 because these two operations were arranged in the reverse order, that is from traditional methods (which is assumed to be less efficient) to the mechanized system (assumed to be the more efficient technique in terms of loss reduction). Therefore in the graphs, a positive association between threshing and/or cleaning with a given dependent variable exhibits a negative slope instead of a positive one as the scale is increased depicting higher efficiency in terms of loss reduction with mechanical equipment.

The charts prepared for each regression model contain most of the quality variables and post-production tasks even though some of them were not significantly associated with variations in the dependent variables.

The point of origin in the charts was set at 10 and 1 percentage points instead of the standard 0 origin because of the very low b - values of some of the variables.

Summary of Findings

Physical Loss Response Functions. Result of the analysis showed that the R^2 (coefficient of determination or coefficient of multiple correlation) value obtained from the THLOSS model was quite low indicating that other relevant variables were left out, although the F-test for the entire model showed significant results. Of the combined physical and quality deterioration factors considered to affect variability in the amount of THLOSS, four were found significant-- plot size, man hours harvesting, percent brokens and interaction between elapsed time from harvesting to threshing and threshing to drying (ETHVTH). Except for man hours in harvesting (MDHVHA) all the other significant variables exhibited the right expectations (Table 9). Possible reason for this behavior is discussed later.

In the MILLREC model, the quality characteristics showing significant association with variability in total milling recovery in threshing were impurity and other varieties (Table 10). Both variables exhibited negative association with variability in total milling yield (Figure 4). Other significant variables observed in the model include man hours threshing (MDTHHA), elapsed time from threshing to drying (ETTH), timeliness in harvesting, and interaction terms such as method of threshing by moisture content (THRHMC) and by cracked kernels (THRHCRAK), method of cleaning by impurities (CLENIMPU) and moisture by cracked kernels (MCRACK). With the exclusion of timeliness in harvesting, all the other significant variables exhibited signs consistent with expectations and possible reasons are presented later.

Forty-two percent of the variation in total milling recovery during threshing is explained by the combined explanatory variables considered in the model. R^2 value for the entire model is highly significant (Appendix Table D-4).

Table 9. Summarized result of the functional relation between threshing loss (THLOSS) and the combined explanatory variables, Philippines, 1975-1977.

Explanatory Variable	b - values
Intercept	299.160
Thresh (Method of threshing)	273.788
Clean (Method of cleaning)	- 156.614
Plot Size (in square meters)	0.167 **
Region (Central Luzon or Bicol)	24.421
MDHVHA (Man hours harvesting/ha)	- 39.317 *
ETHV (Hours elapsed from harv. to thresh)	- 0.034
ETTH (Hours elapsed from thresh to dry)	- 0.030
ETHVTH (ETHV/ETTH)	3.376E-05**
Brokens (% brokens in milled product)	28.816 **
Impurity (% chaff + % weed seeds)	26.963
THRHBROK (Thresh/Brokens)	- 7.172
THRHIMPU (Thresh/Impurity)	- 23.938
R^2	0.235**

** Highly significant at .01 level.

* Significant at .05 to .10 level.

Table 10. Summarized result of the functional relation between total milling recovery (MILLREC) and the combined explanatory variables in threshing and drying operation, Philippines, 1975-1977.

Explanatory variables	Total Milling Recovery: Threshing	Total Milling Recovery: Drying
	b - values	
Intercept	65.927	67.879
Moisture (% moisture content)	0.170	0.109
ChalkyK (% chalky kernels)	0.038	- 0.128 *
Impurity (% chalf + weed seeds)	- 0.839 **	- 0.630 **
CrackK (% cracked kernels)	- 0.216	- 0.610 **
FermentK (fermeted kernels)	0.164	0.294 *
DamageK (% damaged kernels)	- 0.064	- 0.164
Othervar (% other varieties)	- 0.204 **	- 0.066
Harvest (Timeliness of harvest)	0.492 *	0.157
Thresh (Method of threshing)	1.828	1.895
MDTHHA (Man hours threshing/ha)	0.280 *	0.110
ETTH (Hours elapsed from thresh. to dry)	0.0004 *	0.00013
MDETTH (MDTHHA/ETTH)	- 6.303E-05	- 2.249E-05
ETTHFERK (ETTH/FermentK)	- 6.168E-05	1.899E-05
CLENIMPU (Clean/Impurity)	0.138 *	0.178 **
THRHCRAK (Thresh/CrackK)	- 0.103 *	0.113 *
THRHBROK (Thresh/Brokens)	- 0.009	- 0.022 *
MCRACK (Moisture/CrackK)	0.019 *	0.014 *
THRHMC (Thresh/Moisture)	- 0.1009 *	- 0.114 *
R^2	0.423**	0.390**

** Highly significant at .01 level.

* Significant at .05 to .10 level.

In the drying operation, the quality characteristics which were found to be significantly associated with reduction in total milled rice include impurities, cracked, fermented and chalky kernels (Table 10). Except for fermented kernels, the other inferior quality characteristics exhibited negative signs consistent with expectations (Figure 5). Interaction terms such as method of threshing by percent cracked kernels (THRHCRAK) broken kernels (THRHBROK), and moisture content (THRHMC), method of cleaning by percent impurities (CLENIMPU) and moisture content by cracked kernels (MCRACK) were also found significant. Of these variables, two did not exhibit the right expectations, THRHCRAK and MCRACK.

A relatively lower R^2 value was obtained in this model although the F-test indicates that the total model is highly significant.

<u>Quality Deterioration Response Functions</u>. The variables exhibiting significant association with variability in percent head rice recovery in the threshing operation include cracked and chalky kernels and the interaction between man hours harvesting and the elapsed time from harvesting to threshing (MDETHV). Cracked kernels exhibited negative association with percent head rice while chalky kernels which were expected to show a negative relation, show a positive b-value (Figure 6). Possible reasons for this behavior is discussed later. The R^2 obtained is quite low indicating that other relevant variables were not included in the model. However, the F-value for the entire model is highly significant (Table 11).

In the HDRICE model in the drying operation, more variables were considered since this task is the final step in the sequence of post-production operations before milling. The quality characteristics significantly associated with variability in percent head rice during drying

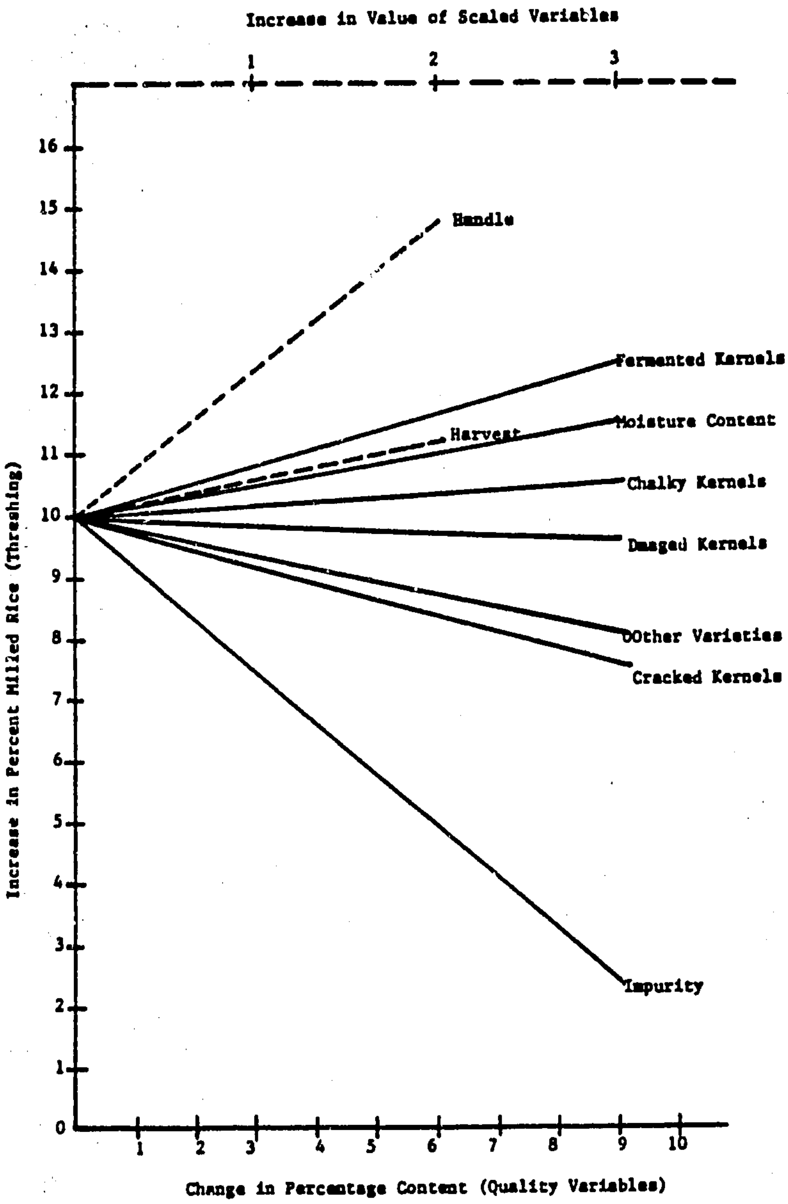

Figure 4. Relationship between percent milling recovery in threshing and the combined explanatory variables

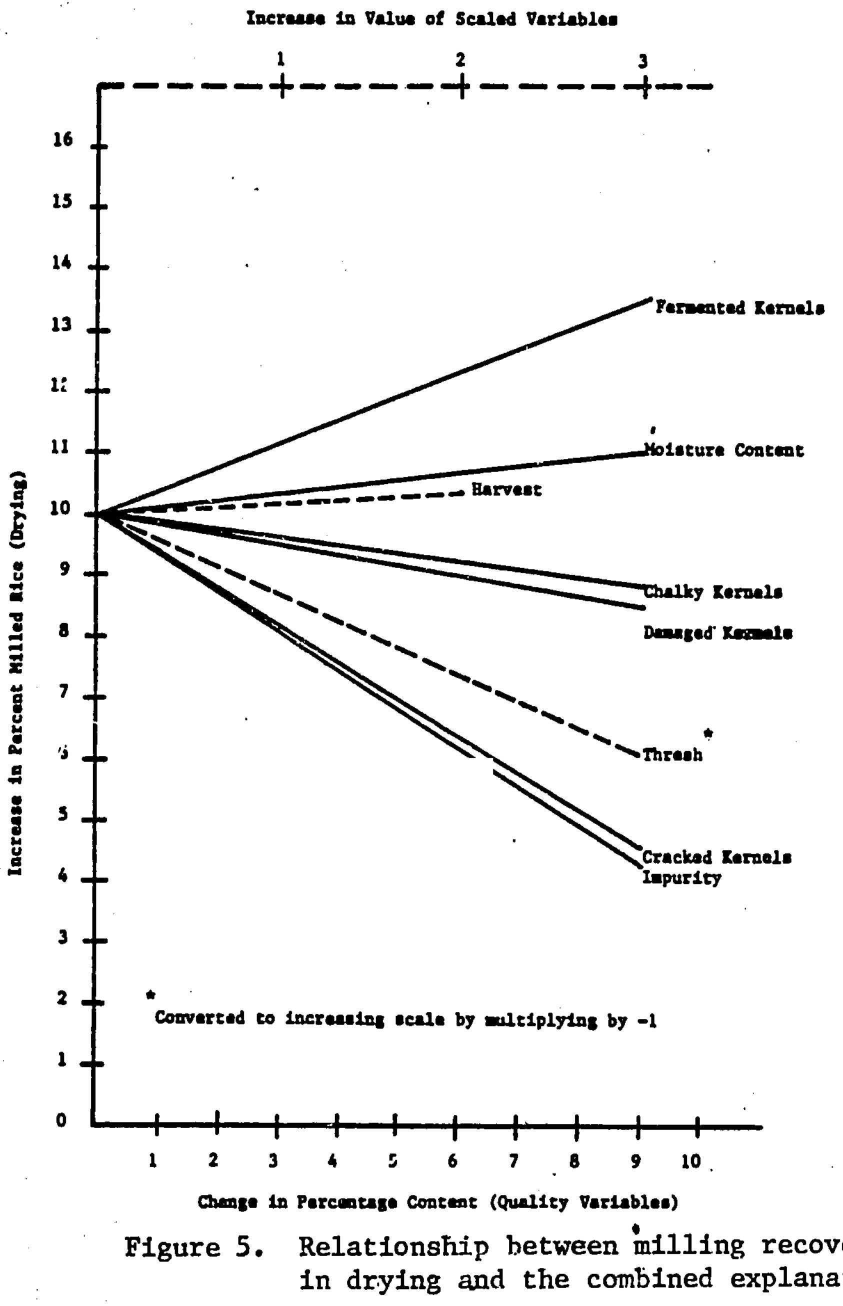

Figure 5. Relationship between milling recovery in drying and the combined explanatory variables

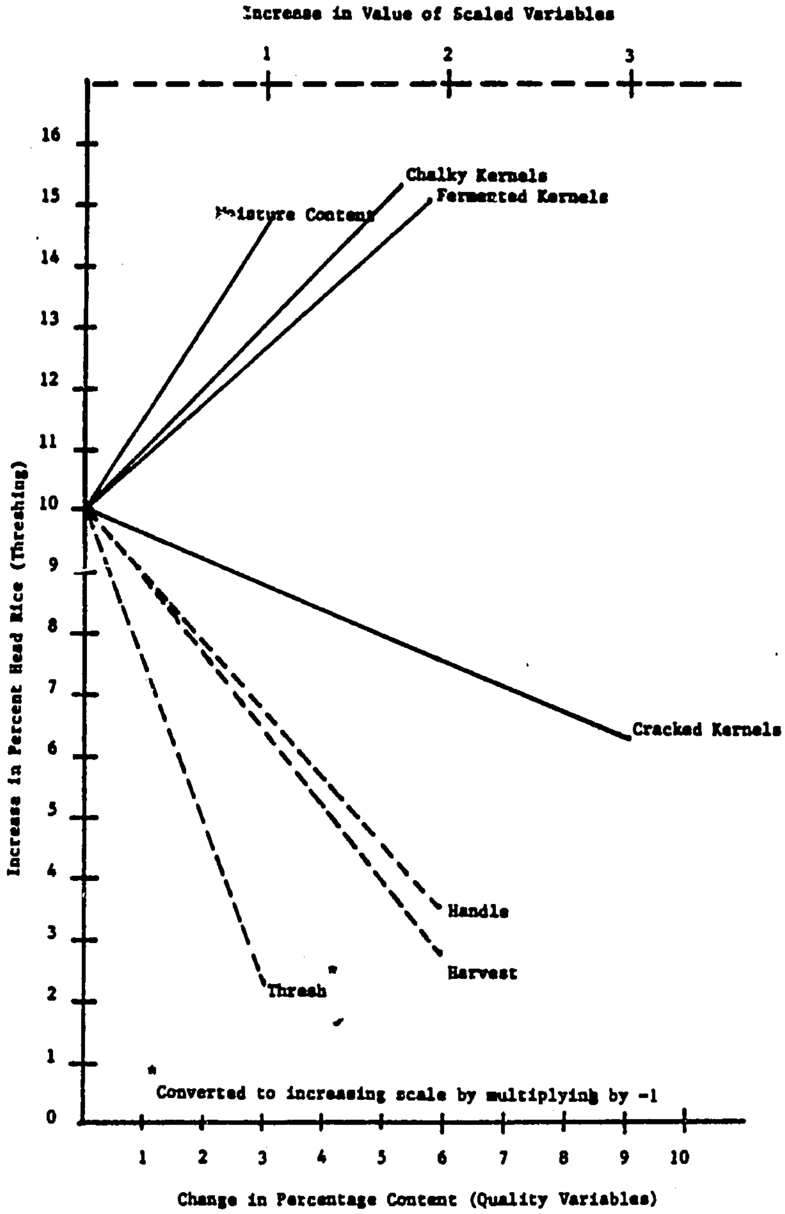

Figure 6. Relationship between percent head rice in threshing and the combined explanatory variables

are cracked and fermented kernels. Both variables exhibited negative association with head rice recovery since they represent inferior quality characteristics. Among the remaining explanatory variables, timeliness in harvesting and handling, total elapsed time from harvesting to drying (ETDR) as well as region were found significantly associated with variability in percent head rice. Interaction terms such as method and timeliness of drying by fermented kernels (DRYFERK), damaged kernels (DRYDAM) and cracked kernels (DRYCRAK) were also found significant (Table 11). Except for timeliness in harvesting, all the explanatory variables exhibited the right expectations (Figure 7). The wrong sign of this variable is indicative of other factors that might have contributed to early or delayed harvest other than maturity of the crop. Detailed discussion is presented later.

A relatively higher R^2 value was obtained in this model indicating that the impact of alternative post-production technologies on percent head rice recovery is especially pronounced at the drying stages. The F-test for the entire model shows the R^2 value to be highly significant.

In the GRADE model in the threshing operation, the variables showing significant association with variability in the grade of milled rice are moisture content, fermented kernels, timeliness in handling, region, elapsed time from harvesting to threshing (ETHV) and crop maturity (Table 12). Of the interaction terms considered, elapsed time from harvesting to threshing by elapsed time from threshing to drying (ETHVTH) and timeliness in handling by moisture content (HANDMC) were found significant. Except for elapsed time from harvesting to threshing and timeliness in handling, all the significant variables exhibited signs consistent with expectations (Figure 8).

Table 11. Summarized result of the functional relation between head rice recovery and combined explanatory variables in threshing and drying operations, Philippines, 1975-1977.

Explanatory Variables	Head Rice Recovery	
	Threshing	Drying
	b - values	
Intercept	62.154	70.279
CrackK (% cracked kernels)	- 0.407**	- 1.574*
DamageK (% damaged kernels)	3.698	1.635
ChalkyK (% chalky kernels)	1.048**	0.167
FermentK (% fermented kernels)	0.559	- 2.783*
Moisture (% moisture content)	0.670	
Impurity (% Chalf + % weed seeds)		- 0.129
Harvest (Timeliness of harvest)	- 1.796	2.381*
Handle (Timeliness of handling)	- 1.608	- 2.067*
Thresh (Method of Threshing)	8.421	0.504
Clean (Method of Cleaning)		- 2.394
Dry (Method and timeliness of drying)		- 0.607
Region (Central Luzon or Bicol)	- 2.946	5.564*
MDHVHA (Man hours harvesting/ha)	0.074	0.780*
MDTHHA (Man hours threshing/ha)	- 0.509	
MDDRHA (Man hours drying/ha)		29.687
ETHV (Hours elapsed harv. to thresh.)	0.0022	0.002
ETDR (Hours elapsed harv. to dry.)		0.0009*
MDETHV (MDHVHA/Harvest)	- 0.00036*	- 0.0003*
MDETDR (MDDRHA/Dry)		- 0.0008*
HARVMC (Harvest/Moisture)	0.172	
THRHMC (Thresh/Moisture)	- 0.431	
THRHDAM (Thresh/DamageK)	- 0.991	
DRYFERK (Dry/FermentK)		0.892*
ETTHFERK (ETTH/FermentK)		- 0.00016
DRYDAM (Dry/DamageK)		- 0.836*
CLENIMPU (Clean/Impurity)		0.31?
THRHCRAK (Thresh/CrackK)		0.166
DRYCRAK (Dry/CrackK)		0.229*
R^2	0.310**	0.398**

**Highly significant at .01 level.

*Significant at .05 to .10 level.

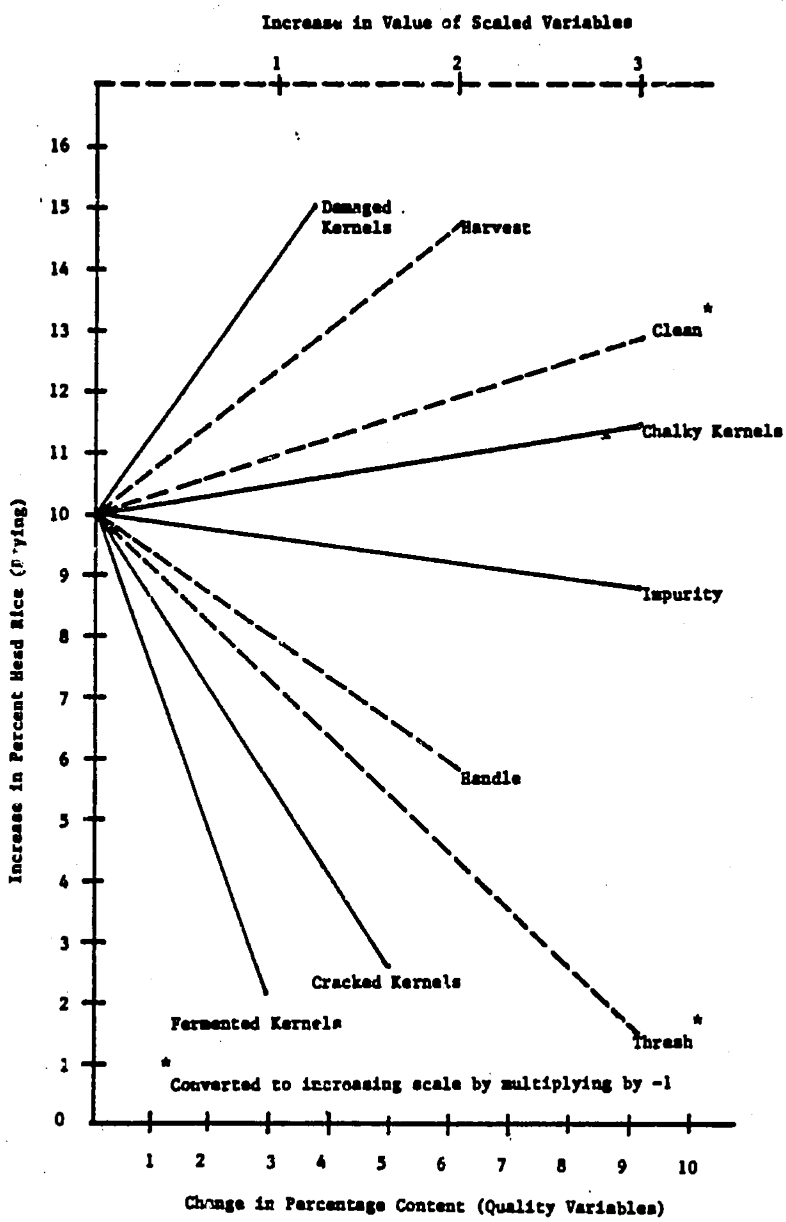

Figure 7. Relationship between percent head rice in drying and the combined explanatory variables

Table 12. Summarized result of the functional relation between grade of milled rice and combined explanatory variables in threshing and drying operation, Philippines, 1975-1977.

Explanatory Variables	Grade of Milled Rice	
	Threshing	Drying
	b - values	
Intercept	0.327	- 0.751
Moisture (% moisture content)	0.077 **	0.053 **
CrackK (% cracked kernels)		- 0.033
FermentK (% fermented kernels)	0.084 *	0.050
Harvest (Timeliness of harvest)		0.631 **
Handle (Timeliness of handling)	- 0.738 *	- 1.049 **
Thresh (Method of threshing)		0.094
Clean (Method of cleaning)	- 0.047	
Dry (Method and timeliness of drying)		0.086
Region (Central Luzon or Bicol)	- 0.778 **	- 0.692 **
MDHVHA (Man hours harvesting/ha)	- 0.005	- 0.042
MDTHHA (Man hours threshing/ha)		0.003
MDDRHA (Man hours drying/ha)		1.051 *
ETHV (Hours elapsed harv. to thresh.)	- 0.0001 *	- 0.0001
ETTH (Hours elapsed thresh. to dry.)	- 2.70E-05	- 0.0002*
ETDR (Hours elapsed harv. to dry.)		0.0002
Lodge (Lodging index of variety)		0.036
Maturity (Maturity days for variety)	0.010 *	0.014 *
ETHVTH (ETHV/ETTH)	1.64E-08*	4.01E-08**
ETHVDR (ETHV/ETDR)		- 2.55E-08**
MDETHV (MDHVHA/Harvest)	9.78E-06	2.69E-05**
MDETTH (MDTHHA/ETTH)		- 8.59E-06**
HARVMC (Harvest/Moisture)		- 0.028 **
HANDMC (Handle/Moisture)	0.033 *	0.044 **
HARVFERK (Harvest/FermentK)		- 0.049 *
HANDFERK (Handle/FermentK)	0.008	
ETHVFERK (ETHV/FermentK)		- 2.28E-05*
ETTHFERK (ETTH/FermentK)	- 8.41E-06	
DRYFERK (Dry/FermentK)		- 0.037 *
MCFRMENT (Moisture/FermentK)		0.008 *
MCRACK (Moisture/CrackK)		- 0.003 *
THRHCRAK (Thresh/CrackK)		- 0.020 *
HANDCRAK (Handle/CrackK)		0.018 *
DRYCRAK (Dry/CrackK)		0.013 *
R^2	0.394**	0.580**

** Highly significant at .01 level.

* Significant at .05 to .10 level.

The R^2 value obtained in the model was quite low indicating that other relevant variables were left out. However, the F-tests indicates that the total model is highly significant.

In drying, all the different post production tasks from harvesting to drying were significantly associated with milled rice grade. Labor inputs and delays in the performance of subsequent post production tasks likewise exhibited significant impact on grade. Among the interaction terms, the degree of fermentation and cracking combined with alternative tasks also were found to significantly influence variability in rice grade (Table 12).

The following significant variables exhibited the expected positive association with milled rice grade indicating that their presence contribute to an increase in numerical grade (reduction in market quality of milled rice) (see Figure 9):

(a) moisture content (MC)

(b) timeliness in harvesting (harvest)

(c) man hours in drying (MDDRHA)

(d) maturity

(e) moisture by fermented kernels (MCFERK)

(f) moisture by cracked kernels (MCRACK)

(g) man hours by elapsed time in harvesting to threshing (MDETHV)

(h) timeliness in handling by moisture content (HANDMC)

(i) timeliness in handling by cracked kernels (HANDCRAK)

(j) timeliness and method of drying by cracked kernels (DRYCRAK)

Negative association with numerical grade of rice were exhibited by region, method of threshing by cracked kernels (THRHCRAK) and method

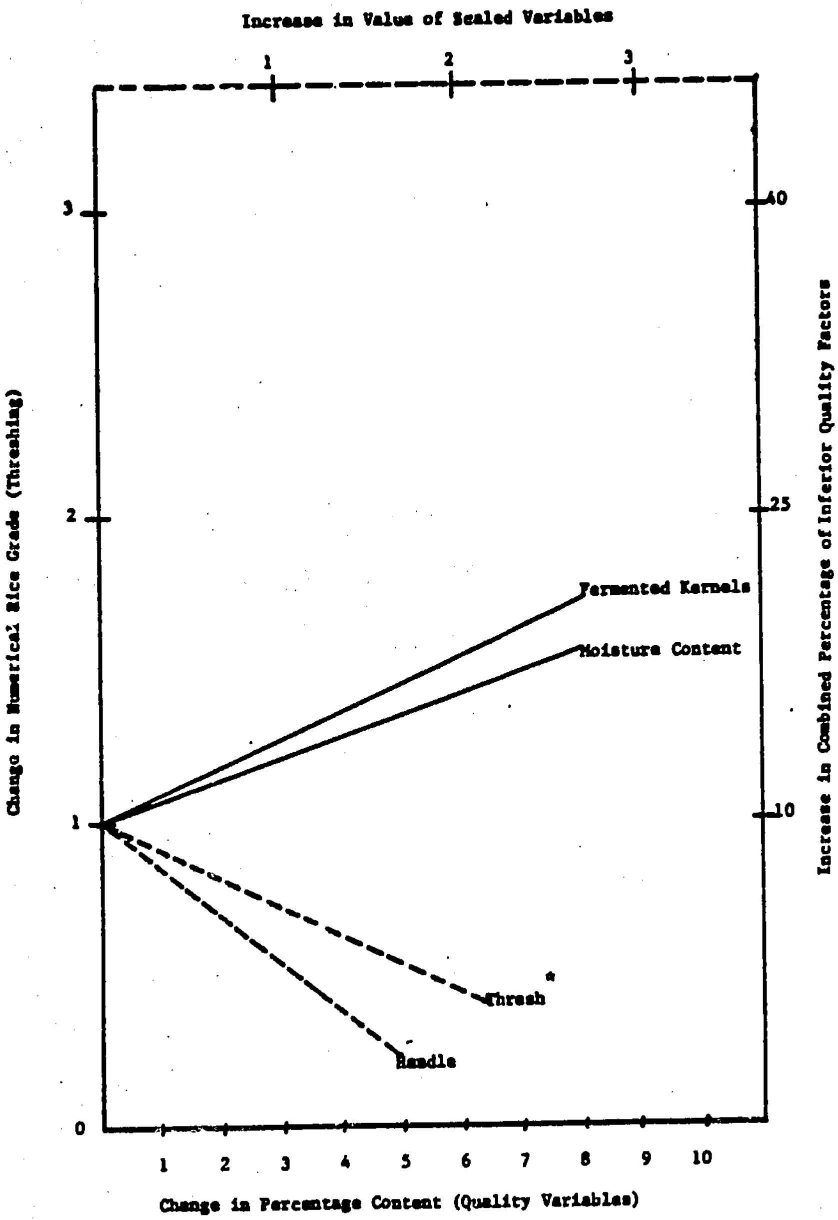

Figure 8. Relationship between change in numerical rice grade during threshing and the combined explanatory variables

and timeliness of drying by fermented kernels (DRYFERK). Timeliness in handling, elapsed time from threshing to drying (ETTH), and interaction between timeliness in harvest by fermented kernels (HARVFERK) and timeliness in handling by moisture content (HANDMC) which were expected to show positive association with rice grade also exhibited negative relation (Figure 9).

Fifty-eight percent of the variation in grade of milled rice was explained by the combination of independent variables considered in the model. The F-value for the total model was highly significant.

Factors Influencing Threshing Loss, Rice Recovery and Grade

Plot Size. A positive relation was found between size of plot and the amount of physical loss in threshing per hectare. This is indicative of the magnitude of loss per hectare that is likely to occur as the area of land increases. Harvesters tend to be less careful and inefficient when they work on larger land areas since they want to compete with the other landless tenants in harvesting more crops to increase their share of the total harvest. The problem is further aggravated by concurrent harvests within a given village or locality, further encouraging harvesters to cover as much land as possible. The result is haste and waste in the completion of the task.

Man Hours in Harvesting (MDHVHA), Whether labor requirement in harvesting should show positive or negative association with the amount of physical loss in threshing depends on whether the increase or decrease in labor input is a reflection of lesser or greater efficiency in the performance of the task or due to factors other than the skill of the

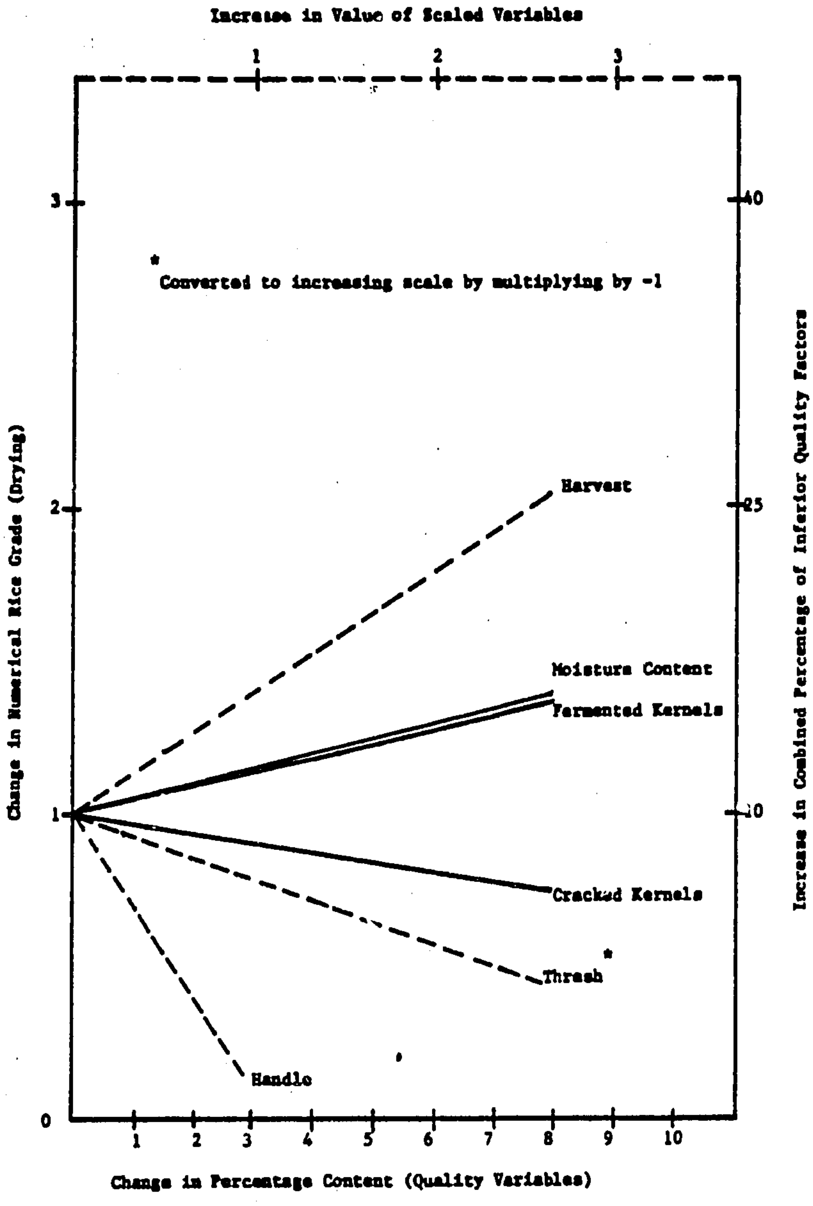

Figure 9. Relationship between change in numerical rice grade during drying and the combined explanatory variables

harvester. Among the other conditions that might affect amount of labor utilized in harvesting include: (a) presence or absence of immature or unfilled grains mixed with mature panicles of grain which require more time and care in harvesting, (b) tungro-infested plots which require careful selection of healthy grains, (c) weedy fields, (d) inclement weather resulting in muddy or flooded fields and causing difficulty in the execution of the task, (e) availability of harvesters during peak months, and (f) age, sex and skill of harvester. Ezaki (47) reported that harvesting output of a skilled man in non-lodged rice variety is about 0.01 ha/hr and that of woman is about 0.006 ha/hr. The indicated negative association between man hours harvesting and threshing loss is not statistically significant (Appendix Table D-1).

Harvest. The timing of harvest and the moisture content of paddy all determine the ease with which the rice shatters, allowing grains to fall onto the ground or mud, either while the crop is standing or during the harvest process. The timing of harvest impacts two other steps (a) pre-threshing handling and (b) milling.

Handle. The fewer number of times paddy is handled prior to threshing the lower the losses. This was the observation of Duff and Samson (48) when they noted that there are zero handling losses and low threshing losses when rice is threshed immediately after harvest. They reported that each additional handling step embodies a loss from 1 to 2 percent particularly for varieties with high shattering characteristics. The variable was not statistically significant in the regression equation but the positive b - value is consistent with expectations (Appendix Table D-1).

Timeliness in Harvesting and Handling. Delays in these two post-production operations expose the grain to weather hazards resulting in kernel deterioration and possible fissuring or sun-checking. When dry paddy is left overnight out in the field or gets moistened by any other means, it takes up water and fine crosswise cracks appear in the grain. Such cracks are visible shortly after the water content of the paddy rises, and eventually remain when the rice is finally dried. The presence of such grains is one of the main contributory causes for sharp decreases in percent head rice during milling. As noted in Table 5, timely harvest and handling resulted in significantly higher head rice recovery than delayed operations. Table 6 also showed that significantly fewer cracked kernels were obtained from samples collected under timely handling compared to delayed operation.

The drier the paddy, the greater and quicker is the formation of cracks after a rise in moisture content (49). And one factor that influences the degree of paddy dryness while left in the field awaiting threshing is the method of stacking. An experiment conducted in Surinam (49) showed that harvested paddy spread on stubbles dried very quickly and after 3 days resulted in a sudden decrease in percent whole grains due to remoistening during the night. In comparison, the harvested paddy stacked upright in sheaves dried more slowly and there was practically no decrease in percentage of whole grains recovered even after eight days of stacking.

In the third method of stacking, the sheaves were leaned against "Heinzen" which essentially consist of a framework of horizontal laths some 2 meters in length supported on uprights stuck in the ground. Over the upper lath a sheaf is hung so that the standing sheaves are partly covered and protected against rain, while a draft is ensured. With the covered sheaves, the drying was so slight that over a period of eight days the moisture content remained far above the critical point for sun cracking. Consequently the percentage of whole grains remain unchanged.

The results of the above experiment can probably explain the inconsistent behavior of timeliness in harvesting and handling as it relates to the amount of head rice, total milling yield and grade of milled rice.

In terms of percent head rice in the threshing operation, harvest exhibited the expected negative association although the b - value was not significant (Appendix Table D-2). Conversely, a positive significant association was noted between delayed harvest and percent head rice in drying (Appendix Table D-3).

In the loss response function for milling yield, delayed harvest consistently exhibited positive association in both threshing and drying operations with a significant b - value in threshing (Appendix Table D-4 and D-5).

Finally, delayed harvest was positively associated with numerical grade of milled rice and the b - value was significant (Appendix Table D-7).

With delayed handling, the variable's negative b - value in percent head rice in threshing and drying is consistent to expectations. However, only the b-coefficient in drying was significant (Appendix Table D-2 and D-3).

In terms of total milling yield in threshing and reduction in numerical grade for both operations, delayed handling exhibited the wrong sign (Appendix Tables D-4 to D-7).

Method of Threshing. The machine or equipment used in threshing operation is significantly associated with the amount of head rice recovered after threshing and drying. The method of threshing will contribute to losses if carried out in a manner that results in the cracking of grains. Even mechanical threshers may cause excessive breakage of grains if used improperly or fed with poor quality paddy. This was evident from the results of the field trials which showed significantly higher percent head rice in systems using the threshing frame (hampasan) over that of the axial-flow thresher (Table 5).

The method of threshing was positively associated with head rice yield in both threshing and drying and their b - values were significant (Appendix Tables D-2 and D-3). The same positive behavior was observed for total milling recovery and rice grade during drying operation although the b-coefficients were not statistically significant (Appendix Tables D-5 and D-7).

Interaction between Method of Cleaning and Inferior Quality Characteristics. Due to the farmer's practice of threshing even high moisture paddy when using mechanical threshers, reduction in percent head rice and total milling yield occurred. This is illustrated by the negative association between percent head rice in threshing and total milling recovery in threshing and drying with the interaction term thresh by moisture content (THRHMC). The b-coefficient was significant in all the models (Appendix Tables D-2, D-4 and D-5).

Similarly, because of the poor quality of paddy fed into the machine, a negative association was obtained between total milling recovery and the interaction term thresh by broken kernels (THRHBROK). This negative association was significant in the drying operation but not in threshing which again confirms the general observation that the impact of qualitative factors on the final product is more pronounced at the drying stages (Appendix Tables D-4 and D-5).

Moisture Content. Milling quality is influenced by moisture content of rice at harvest time, during drying and storage and while milling (50). Rice of high milling quality must be harvested at the right stage of maturity, properly dried, stored and milled under moisture conditions optimum for minimum breakage. The optimum moisture content for harvesting is 21 to 24 percent and the threshold value for safe storage and milling is 14 percent (51).

During the implementation of the field trials, the moisture content of newly harvested paddy ranged from 18 to 25 percent (wet basis) during the dry season and 20 to 30 percent (with some even exceeding the 30 percent level) during the wet season. Under such conditions, paddy deteriorates quickly resulting in loss of quality in the form of damaged, discolored and germinated kernels.

Moisture content was found to be significantly associated with head rice recovery during threshing. However, it exhibited the wrong sign, which can be due to the lack of control during the implementation of the field trials or it could mean that the moisture content is still in the safe range for milling. In drying operation, moisture content was not a significant variable and was therefore excluded from the model (Appendix Tables D-2 and D-3).

In the loss response function for total milling recovery, moisture content was not a significant variable for either threshing or drying operation and it exhibited the wrong positive sign (Appendix Tables D-4 and D-5).

In the grade of milled rice, moisture content was a significant variable and it showed the expected positive association with change in numerical rice grade both in the threshing and drying operations (Appendix Tables D-6 and D-7).

Cracked Kernels. Grains that have been cracked or broken through intermittent heating and re-wetting while in stacks, or due to rough handling or improper drying easily break during milling operation because of the breakage of the endosperm or weakening of kernels by fissures. Cracked kernels is an inferior quality characteristic and is therefore expected to have an inverse relationship with percent head rice and total milling recovery and a direct or positive association with reduced numerical grade of milled rice.

Cracked kernels consistently exhibited significant negative association with percent head rice and total milling recovery for both threshing and drying operations (Figures 4 to 7). In the function for numerical grade of milled rice, cracked kernels was not significant in the drying operation and exhibited the wrong sign (Appendix Table D-7 and Figure 9).

Damaged Kernels. Grains which are discolored or damaged by water, insects, heat or any other means are classified as damaged kernels. Therefore, depending on the source and degree of damage, this variable may exhibit either positive or negative association with rice recovery and grade.

Results of the analysis show that damaged kernels exhibited positive association with percent head rice in both threshing and drying operations (Figures 6 and 7). The b - values in both operations were not statistically significant (Table 11). In the response function for total milling recovery, damaged kernels exhibited negative association in both operations (Figures 4 and 5) but the b - values were not statistically significant. The damaged kernels variable was excluded from the linear regression models for rice grade because it was one of the quality factors considered in the grading process.

Chalky Kernels. Chalkiness in grain occurs under unfavorable environmental and cultural conditions and when rice is harvested too early and includes immature kernels. Chalky rice not only detracts from the general appearance but is usually weak and therefore breaks easily during milling. It is considered an inferior quality characteristic and is expected to have negative association with variability in percent head rice and milling yield and a positive relation with numerical grade of milled rice.

Chalky kernels displayed positive association with percent head rice in both threshing and drying operations although the b - value was found significant only for threshing (Figures 6 and 7, Appendix Tables D-2 and D-3). This wrong sign may indicate the possibility of a safe range of chalkiness in grain that does not readily result in breakage if milling is performed at the right moisture, temperature and hulling efficiency. In terms of milling yield, chalky kernels again exhibited positive but insignificant association in the threshing operation. In drying, the negative expectation was observed and the b - value was significant.

The chalky kernel variable was excluded from the models for numerical grade of milled rice because it was considered in the grading process.

Fermented Kernels. Since fermentation in grain is a sign of deterioration which sometimes results in foul or musty odor, it tends to lower milling quality and yield.

Results of the analysis reveal some interesting relationships between fermented kernels and the two postharvest tasks in terms of head rice and total milling recovery. In the threshing operation, a positive and significant association was observed between fermented kernels and percent head rice and total milling yield (Figures 4 and 6, Appendix D-2 and D-4). Conversely, in drying, the expected negative association between fermented kernels and percent head rice and total milling yield was noted (Figures 5 and 7, Appendix Tables D-3 and D-5). The values were also significant in both models for drying. This indicates that the impact of fermented kernels on head rice and total milling recovery is especially pronounced at the drying stages.

In terms of numerical grade of milled rice, fermented kernels exhibited the expected positive association which was significant in drying but not for threshing (Appendix Tables D-6 and D-7).

<u>Other Varieties</u>. Foreign grains or grains which differ distinctly from the characteristics of the variety under consideration significantly influence variability in percent head rice. Uniformity in the size of the kernels is a good indication of varietal purity. The lack of uniformity in the size of the grain affects head rice recovery by causing a higher proportion of brokens.

The variable other varieties was retained only in the loss response function for total milling recovery. The expected negative association between other varieties and total milled rice was obtained in both threshing and drying operations although only the b-coefficient in threshing was significant (Tables 22 and 23, Figures 6 and 7).

Impurity. Especially with weedy fields, tall grasses are likely to be cut and get mixed with the harvested paddy stalks during the reaping process. Further admixture of foreign materials is likely to occur when harvested paddy is stacked right in the field on top of stubbles or on dikes or levees without using an underlay. Increases in these impurities can be associated with increases in THLOSS because some of the threshed grain can get caught in these weeds or other foreign material. In some instances, these impurities can cause damage to the threshing and cleaning equipment especially when they involve stones and other sharp objects that may cause breakdown of the machine. The expected positive association was observed although the variable was not statistically significant (Table 9).

The presence of impurities in grains is also a reflection of the efficiency of the threshing and/or cleaning methods used. Impurities reduce the quantity of usable rice, lower milling yield and affect the nutritional value of rice as food. Certain impurities can cause damage to the milling and processing apparatus and reduce its performance and efficiency.

Impurities consistently exhibited negative impact on head rice and milling yield in both threshing and drying operation (Figures 4 to 6). The b - value in the loss response function for head rice in drying was not significant (Appendix Table D-3). However, for total milling yield, the b - values were significant in both threshing and drying (Appendix Tables D-4 and D-5). The variable was excluded from the models explaining numerical grade of rice because it was considered in the grading process.

Brokens. With undue delay occurring during field drying or while the grain is stacked in the field awaiting threshing, it is subjected to alternate re-wetting and drying causing fissures or sun-checks to the grain. The sun-checked grain easily breaks during the milling operation depending on the amount of stress involved. As shown in Table 9, the expected strong positive relation between this variable and THLOSS is highly significant. Although percentage broken kernel is a measure of quality rather than quantity, the variable seems to function as a proxy variable for loss in physical quantity as well. This might be expected because the same kinds of unfavorable conditions and practices that add to kernel breakage in milling also add to physical losses during harvesting and threshing.

Maturity. Breakage in milling also depends on the age of paddy when harvested. With immature or unripe grains, a considerable proportion is broken during milling, but this diminishes as the rice ripens. There is an optimum period of from one to three weeks at which the rice should be cut to give the best milling yield. Within these limits, the drier the season, the shorter this optimum harvesting period (49).

Grain maturity was found to be significantly associated with grade of milled rice. The positive association of grain maturity to numerical grade is consistent to expectations (Figures 8 and 9).

CHAPTER IV

COMPARATIVE ANALYSIS OF ALTERNATIVE POST-PRODUCTION SYSTEMS

The primary objective of the comparative analysis is to measure the economic potential of alternative post-production systems over that of the traditional systems currently practiced in the area normally measured as the projected comparative rate of return on added capital investment. The analytical methods of assessing investment worth can help identify which of the different post-production alternatives will be most efficient. However, it is not the intention of this study to select only one best alternative because many factors other than quantitative or even purely economic considerations must be considered in selecting post-production systems. The purpose of the economic analysis is to improve the quality of the selection decision, not to substitute for it.

In comparing efficiencies among alternative post-production systems, analysis by postharvest operations was not feasible because of the varied conditions existing between the mechanized and traditional postharvest systems. With the axial-flow thresher, the threshing and cleaning operations are performed simultaneously by the machine to deliver clean, threshed, and commercially acceptable grain right after threshing. This is not true with traditional systems using either the threshing frame or the flail and/or stick. Further cleaning is required after threshing to remove some of the impurities mixed with the grain. Therefore, in this study the different post-production systems considered in the comparative analysis represent combinations of different techniques for threshing, cleaning and drying paddy as practiced in the area. The harvesting phase is excluded from the analysis since manual harvesting with scythe or sickle is employed in all the systems studied. While complete data on each entire system have not been available, data on individual processes and equipment have been collected during the field trials. Thus, data for the different systems have been determined by aggregating inputs for each of the three processes using alternative techniques in each process.

Comparative Cash Flow and Return On Investment

The principal measure of economic potential used in the feasibility analysis program is the potential comparative rate of return on investment (CRR) based on the time flow of money into and out of the enterprise. The CRR measures the rate of return to differential total capital investment in an alternative case compared to the base case.

Specification of Alternatives for Analysis

In this study, the basic model to which alternative cases are compared is the traditional system of threshing, cleaning and drying commonly practiced in each of the regions. In Central Luzon, the basic model is the traditional system of using the frame (hampasan), cleaning with the aid of the winnowing basket (bilao) and drying the paddy under the sun. In Bicol, two traditional systems of threshing were observed; (1) use of the flail and/or stick combined with manual treading and, (2) use of the threshing frame (hampasan). However, since the former is the more popularly used threshing method among the farmers studied, it is the one considered in the base case, and the latter is considered as an alternative. The base case for Bicol, therefore, consists of threshing with the flail and/or stick, cleaning with the use of wooden winnower (hungkoy) and drying under the sun.

One alternative considered in the analysis is the fully mechanized system of threshing and drying using the axial-flow thresher and batch dryer. Other alternatives represent combinations of mechanical threshing and sun drying or traditional threshing and mechanical drying as summarized in Table 13.

Application of Comparative Rate of Return (CRR) Analysis

The economic potential of alternative post-production systems is determined by relating the comparative rate of return obtained to the relevant opportunity cost of capital. A calculated comparative return which is higher than the relevant opportunity cost of capital indicates that the alternative system is feasible and profitable. A calculated comparative return lower than the opportunity cost of capital indicates that the more capital-intensive alternative is not feasible.

The opportunity cost of capital is the net annual earning power of capital in alternative investments in the society. It is usually approximated closely by the prevailing market rate of interest on relatively risk-free capital loans, after adjustment for an anticipated rate of inflation in the economy (in order to adjust the monetary market rate of interest to real terms).

In this study, six different rates of interest were used to reflect opportunity cost of capital, namely 5, 8, 12, 25, 30, and 35 percent per annum. The 5 and 8 percent interest rates were included to

Table 13. Alternative postharvest system considered in the comparative analysis by region, Philippines, 1975-77.

Postharvest System	Description
Central Luzon	
1 - Traditional System (base case)	Traditional system of threshing using the frame (hampasan), cleaning with the winnowing basket (bilao) and paddy sun drying
2 - Fully mechanized (alternative)	Mechanized system of threshing and drying using the axial-flow thresher and twin-bed batch dryer
3 - Combined mechanical and traditional (alternative)	Mechanical threshing/cleaning combined with sun drying
4 - Combined traditional and mechanical (alternative)	Traditional system of threshing using "hampasan", cleaning with "bilao" combined with mechanical drying
Bicol Region	
1 - Traditional system (base case)	Traditional practice of threshing using flail/stick combined with manual treading cleaning using wooden winnower (hungkoy) and paddy sun drying
2 - Fully mechanized (alternative)	Mechanized system of threshing and drying using axial-flow thresher and batch dryer
3 - Combined mechanical and traditional (alternative)	Mechanical threshing/cleaning combined with sun drying
4 - Combined traditional mechanical (alternative)	Traditional threshing and cleaning using the frame, wooden winnower and mechanical drying
5 - Combined traditional mechanical (alternative)	Traditional threshing and cleaning using flail/stick, wooden winnower combined with mechanical drying
6 - Alternative traditional practice	Postharvest system of threshing using the frame, wooden winnower and drying paddy under the sun

reflect conditions of highly subsidized credit as is often practiced in developing countries, particularly in the agricultural sector. As discussed in Chapter 2 under the section on Machinery Acquisition, 8 percent was the interest rate charged to the Farmers' Association in the acquisition of postharvest equipment (mechanical threshers and dryers) used in the field trials.

The annual rate of 12 percent was used in the analysis since it approximates the prevailing official lending rate in rural credit institutions. On the other hand, under a relatively capital scarce situation as often prevails in the Philippines, the true market interest rate is likely to be higher, as reflected by the interest rate charged by private money lenders who continue to do business in the rural areas. These interest rates have ranged from 20 to as much as 50 percent on a per annum basis. To approximate the true market rates of interest, the rates of 25, 30, and 35 percent were used.

The guidelines which were followed in developing investment outlay and cost and benefit schedules for the comparative rate of return analysis include the following:

1. The length of the planning horizon encompasses the useful life of alternative postharvest machinery and equipment.
2. Capital outlay for equipment of shorter life than the planning horizon (20 years in this study) was re-entered as replacement cost as often as necessary. Credit was taken for depreciated value of facilities at the end of the 20-year planning horizon.
3. No interest, depreciation nor income tax was included in the comparative cost schedules. Depreciation was excluded to

eliminate double counting because the full original investment and replacement costs were entered to the cash flow in the capital outlay schedule. Interest expense was excluded in order to accurately reflect the earning power of the total incremental capital investment for the alternative regardless of how the capital was obtained and what annual payment was made for its use. Income tax was excluded because the analysis was designed to measure total earning power, regardless of how earnings were allocated.

4. All prices were maintained at constant real level as existing in the two regions studied.
5. Investment cost and benefit figures were expressed in pesos per 100 metric tons on a per annum basis.

The format of analysis presented in Appendix F indicates the standard output of the CRR computer program which was used to evaluate each of the alternative postharvest systems. The printed output includes a tabular listing of the complete 10 columns of input data as well as the output table showing the comparative investments, costs and benefits (premiums) between the base and alternative cases by period, the discounted present value of the comparative net cash flow by period, and the measures of economic feasibility for the alternative systems. The measures of feasibility include the comparative rate of return shown at the top of the output table, the comparative ratios, and the comparative net present values at specified annual discount rates shown at the bottom of the output printout table.

Sensitivity Analysis

In addition to determining efficiency among alternative systems, the analysis was designed to test the sensitivity of the comparative rate of return and net present values to differing price premiums, rates of interest for the use of capital, and real wage rates for labor.

Assumptions and Data Used in the Analysis

Total Capital Outlay

The required capital investment used for alternative postharvest technologies was the acquisition cost of equipment per annual capacity expressed in 100 metric tons of threshed, cleaned, and dried paddy.

Hourly capacities for equipment were taken from the actual machine performance observed during the field trials in the two regions. For the observed hourly capacities, annual capacities were computed for each region after making assumptions on the normal utilization of equipment (Appendix G).

The capital outlays for the base and alternative cases were entered period by period just as the outlay would be made over the planning horizon of 20 years. For the mechanical threshers and dryers, salvage values were assumed at the end of each useful life (8 years for the dryer and 6 years for the axial-flow thresher) while for the manually operated equipment, scrap values were assumed to be zero.

The replacement of worn-out equipment was entered in the appropriate period as net replacement cost (i.e. total cost minus any recovered salvage value for the replaced equipment). The remaining depreciated value of the machine and/or equipment was entered as a negative investment at the end of the planning horizon.

Table 14. Average labor requirement per hectare and per ton among alternative post-production operations by region, Philippines, 1975-77.

Post-Production Tasks	Per Hectare		Per Ton	
	Central Luzon	Bicol Region	Central Luzon	Bicol Region
		man hours		
Harvesting				
Timely harvest	88.97	103.83	24.31	27.57
Delayed harvest	118.72	102.27	36.28	31.61
Handling				
Timely handling	36.71	45.87	10.93	13.14
Delayed handling	41.84	46.05	11.78	14.20
Threshing				
Threshing frame	82.37	90.40	25.79	26.15
Flail/stick	59.19	122.60	13.56	38.65
Axial-flow thresher	31.07	28.76	8.28	9.56
Cleaning				
Winnowing basket	33.43	-	10.21	-
Wooden winnower	-	32.69	-	10.003
Axial-flow thresher	(combined with threshing task)			
Drying				
Timely sun-drying	18.38	31.99	5.30	9.27
Delayed sun drying	23.27	32.04	6.25	9.96
Timely batch drying	9.21	13.26	2.50	3.54
Delayed batch drying	10.41	14.31	3.02	4.25

Annual Operating Costs

Annual expenses for the base case and alternatives were entered from start-up forward through the planning horizon. The operating costs considered in the analysis include labor, repairs and maintenance, fuel, oil and grease, as discussed below; low values (to reflect the quantitative loss among alternate systems) and the price premium for good quality rice were also considered. Similar to the total capital outlay, operating expenses were expressed per 100 metric tons of threshed, cleaned and dried paddy.

Labor. The labor input for each postharvest operation was taken from the observed and collected data during the village level field trials in the two regions (Table 14). As noted in Chapter 2, labor figures pertain to the net time utilized in the performance of the different post-production tasks since rest periods and breaks for snacks and meals were not considered in the computation of labor requirements.

The wage rate for labor used in the analysis was derived in two ways: (a) based on the prevailing cash farm wages in the study area, and (b) based on the harvester-thresher's share paid-in-kind as a percent of the gross harvest. The minimum wage for farm labor was ₱1.00 per man-hour in Central Luzon and ₱1.25 in Bicol at the time of the study.

Wages actually paid in rice harvesting and threshing often are actually much higher than the prevailing farm wages when they are paid in kind (ranging from one-sixth to one-eighth in Central Luzon; one-sixth to one-tenth in Bicol). In this analysis, one-seventh of the crop was used as average harvester-thresher's fee in Central Luzon and for Bicol one-eighth of the crop was used. The effective wage rate per man hour was imputed from the value of the proportion of the yield paid to labor

Table 15. Average operating cost per ton and per machine operating hour for mechanical threshers and dryers by region, Philippines, 1975-77.

Item	Per Hour		Per Ton	
	Central Luzon	Bicol Region	Central Luzon	Bicol Region
			pesos[1]	
Axial-Flow Thresher				
Gasoline (li)	2.54	4.44	4.28	6.21
Grease (lb)	0.04	0.04	0.08	0.06
Motor oil (li)	0.13	0.13	0.21	0.18
TOTAL FUEL/OIL/GREASE	2.71	4.61	4.57	6.45
LABOR	4.92	8.35	8.28	11.97
Batch Dryer				
Gasoline (li)	1.03	1.50	5.08	8.18
Gerosene (li)	2.09	2.60	10.32	14.15
Motor oil	0.11	0.11	0.57	0.62
TOTAL FUEL/OIL	3.23	4.21	15.97	22.95
LABOR	0.66	0.81	3.24	4.43

[1]Conversion rate during the study period is $1.00 = ₱7.45

divided by the labor input in man hours, i.e.,

$$W = \frac{s\ (Y)\ (P_y)}{L}$$

<u>where</u>: W = wage rate in pesos per man hour

s = sharing arrangement prevailing in the area

Y = yield expressed in 100 MT

P_y = price of paddy in pesos/100 MT

L = labor input in man hours

In the traditional system of payment for harvesting and thresher's share, four post-production operations are usually involved; (1) harvesting, (2) bundling/hauling/stacking, (3) threshing, and (4) cleaning. Therefore, the wage rate imputed from the above formula was based on combined labor input for the four operations, and the result applied to man hours required for each of the four tasks separately.

<u>Annual Repair and Maintenance Cost</u>. The annual repair and maintenance expenses for the postharvest equipment were assumed at 10 percent of annual investment outlay for mechanically powered equipment and 5 percent for manually operated tools.

<u>Fuel, Oil and Grease</u>. The prevailing prices of fuel, oil and grease in the two regions were used in the computation. Actual fuel, oil and grease comsumption as well as the total operating time and capacity utilization of the axial-flow thresher and batch dryer were taken from records collected during the field trials (Table 15).

Comparative Physical Losses and Quality Deterioration

<u>Physical Loss Value</u>. Loss figures for each of the post-production systems were taken from physical losses assessed during the field trials

in two regions as summarized in Table 2. These average percentage figures of losses by postharvest task were added for each alternative postharvest system, and the result applied to crop yields. To arrive at the value of loss, the price of paddy per 100 MT prevailing in the two regions was used.

Quality Premiums. To account for possible price incentives for good quality rice, premiums were considered for systems using mechanical dryers. Apart from the uncertainties of solar drying due to dependence on weather, quality considerations place a distinct advantage on mechanical over sun drying because greater control over and consistency of paddy quality can be achieved with mechanical drying.

Results of the quality loss analysis for milled rice collected during the field trials attest to this quality advantage. Samples obtained from systems using the batch dryer exhibited higher head rice percentages than those incorporating sun drying. The potential price premium per each additional 4 to 5 percent of head rice was assumed to be ₱0.10 per kilogram of milled rice. The value was multiplied by 65 percent which was the assumed rate of rice milling recovery. The obtained figure was then divided by four to account for the marketing services that other sectors of the economy are likely to contribute to move and process the grain from the farm to the consumer. Therefore, only a quarter of the potential price premium was considered for reflection in the market price to producers.[10] This premium payment was

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[10]As discussed previously, greater shares of the total potential premium for producers were considered in the sensitivity analyses.

entered as a benefit (negative cost) in the schedule of comparative costs for alternative postharvest systems using the batch dryer.

Results of the Comparative Analysis

Alternative 1 Mechanical Threshing, Cleaning and Drying

Based on labor paid in cash according to the prevailing wage rate in the two regions, the comparative rate of return to the incremental investment for mechanical threshers and dryers over traditional systems was 34 percent for Central Luzon and nearly 42 percent for Bicol (Table 16). The lower rate of return obtained in Central Luzon is due mainly to the higher loss value (see Table 2) coupled with a higher market price for paddy observed in that region.

When labor is imputed from the harvester-thresher's share paid-in-kind as percent of gross harvest, the comparative rate of return of the mecahnized system over that of the traditional one is increased to 67 percent for Central Luzon and 45 percent for Bicol. The fully mechanized alternative shows a higher comparative rate of return in Central Luzon than in Bicol because of the higher sharing arrangement practiced in Central Luzon..

The comparative rates of return in both regions responded favorably to increasing levels of price premium which were considered in systems using mechanical dryers. With labor paid in cash based on the peevailing farm wages, the CRR in Central Luzon increases from 45 percent at 0.50 percent price premium to 77 percent with premium of 2 percent. In Bicol, the CRR ranges from 52 percent at 0.50 percent premium to 80 percent at 2 percent premium. The comparative rates of return to added investment with mechanized systems are even better under higher price

Table 16. Comparative rates of return in fully mechanized system at alternative added wage rates and price premiums by region, Philippines, 1975-77.

Alternative Wage Rate and Price Premium	Central Luzon	Bicol Region
	percent	
Cash wage and no premium	3[illegible].068	41.672
" " " 0.5% "	45.399	51.695
" " " 1.0% "	56.254	61.415
" " " 1.5% "	66.818	70.936
" " " 2.0% "	77.194	80.325
Wage in-kind and no premium	66.967	44.750
" " " 0.5% "	77.341	54.666
" " " 1.0% "	87.590	64.317
" " " 1.5% "	97.752	73.793
" " " 2.0% "	107.853	83.149

premiums when labor is valued at the harvester-threshers fee prevailing in the area (Table 16).

In terms of net present value expressed in pesos per 100 MT, the fully mechanized postharvest system exhibited positive values of net present worth of the cash flow stream even at higher interest rates whether labor is paid in cash or in-kind for both regions. These net present values further increase with incremental jumps in quality premiums (Table 17). The only exception was obtained from Central Luzon where the comparative net present value is negative when the opportunity cost of capital reaches 35 percent if labor is paid in cash and there is no quality premium. When based on prevailing in-kind wages, an assumed quality premium of one percent and annual opportunity cost of capital at 25 percent, an indicated real net present value of savings to producers by full mechanization is ₱18,445 per 100 MT of paddy harvested in Central Luzon and ₱12,356 per 100 MT of that harvested in Bicol.

The comparative ratios which measure the incremental benefit per peso of incremental investment for mechanical thresher and dryer, are likewise favorable for the fully mechanized system. All the values are well above the break-even point even at higher interest rates whether labor was paid in cash or in-kind for both regions (with the exception of the no premium case in Central Luzon at 35 percent interest and with labor paid in cash). The ratio likewise increases with increasing levels of price premiun (Table 18).

<u>Alternative 2 Mechanical Threshing with Traditional Sun Drying</u>

This system exhibits the highest comparative rate of return over the existing traditional postharvest system of all alternative postproduction systems considered in this study. This is true in spite of

Table 17 . Net present value (₱/100 MT) of fully mechanized system at alternternative added wage rates, price premium and rates of interest by region, Philippines, 1975-77.

Alternative wage rate and price premiums	Central Luzon						Bicol Region					
	5	8	12	25	30	35	5	8	12	25	30	35
Cash wage and no premium	21587	15626	10357	2414	926	-185	30812	22800	15700	4979	2976	1485
" " " 0.5% "	31407	23429	16342	5617	3616	2128	40631	30603	21685	8182	5666	3798
" " " 1.0% "	41226	31232	22326	8820	6305	4442	50451	38406	27670	11385	8355	6112
" " " 1.5% "	51045	39035	28311	12023	8995	6756	60270	46209	33654	14588	11045	8426
" " " 2.0% "	60865	46838	34296	15227	11685	9069	70089	54012	39639	17791	13735	10739
In-kind wage and no premium	51185	39146	28396	12069	9033	6789	33787	25165	17513	5949	3791	2185
" " " " 0.5% "	61005	46949	34381	15272	11723	9102	43606	32967	23948	9152	6480	4499
" " " " 1.0% "	70824	54752	40366	18475	14413	11416	53425	40770	29483	12356	9170	6813
" " " " 1.5% "	30643	62555	46351	21679	17103	13730	63245	48573	35468	15559	11860	9127
" " " " 2.0% "	90463	70358	52335	24882	19793	16043	73064	56376	41452	18762	14550	11440

the absence of benefits from quality premiums foregone by sun drying. Major factors contributing to the high CRR are low capital outlay for sun drying pavement and low total operating costs for sun drying.

Based upon labor paid in cash at the prevailing wage rate in the area, the annual CRR in Central Luzon for the incremental investment in threshers only is 121 percent while in Bicol it is 183 percent. Both regions show CRR's of 191 percent for this alternative when labor is paid in kind in the form of prevailing harvester-thresher shares (Table 19).

Positive net present values were likewise obtained in this system even at high opportunity cost of capital (Table 20). Similarly, the comparative ratios are well above the break-even level even at high opportunity cost (Table 21). Comparative benefit-cost ratios based on in-kind wages range in both regions from 4.7 to 1 at 35 percent discount rate to more than 10 to 1 at 5 percent annual discount rate.

Alternative 3 Traditional Threshing and Cleaning Using Frame and Winnowing Basket and Mechanical Drying, Central Luzon

When the traditional system of threshing and cleaning is combined with mechanical drying, quality premiums to farmers have to be increased to at least 1.2 percent of prevailing market prices for paddy in order to have a positive CRR over taaditional systems both for labor paid in cash and paid in-kind. This is necessary to offset the high capital outlay and operating expenses required for mechanical dryers. The CRR value is negative when premium payment is taken to be 1.0 percent. The alternative is not feasible if premium payment to producers is 0.50 percent and even less feasible when premium payment is disregarded in the analysis (Table 22).

Table 18. Comparative ratios of fully mechanized system of threshing and drying by region, Philippines, 1975-77.

Alternative Wage Rates and Price Premiums	Ratio of Added Savings to Added outlay: Central Luzon						Bicol Region					
	5	8	12	25	30	35	5	8	12	25	30	35
Cash wage and no premium	2.271	2.040	1.787	1.237	1.096	0.980	2.692	2.412	2.108	1.452	1.285	1.147
" " " 0.5% "	2.849	2.559	2.242	1.552	1.375	1.229	3.232	2.895	2.530	1.743	1.542	1.377
" " " 1.0% "	3.427	3.078	2,697	1.867	1.654	1.479	3.771	3.378	2.952	2.034	1.799	1.607
" " " 1.5% "	4.005	3.597	3.152	2.182	1.933	1.728	4.310	3.861	3.374	2.325	2.057	1.837
" " " 2.0% "	4.583	4.117	3.607	2.497	2.212	1.978	4.850	4.334	3.796	2.616	2.314	2.067
In-kind wage and no premium	4.013	3.605	3.159	2.187	1.937	1.732	2.856	2.558	2.235	1.540	1.363	1.217
" " " " 0.5% "	4.591	4.124	3.614	2.502	2.216	1.981	3.395	3.041	2.658	1.831	1.620	1.447
" " " " 1.0% "	5.169	4.643	4.069	2.817	2.495	2.231	3.934	3.524	3.080	2.122	1.877	1.677
" " " " 1.5% "	5.747	5.162	4.524	3.132	2.774	2.480	4.474	4.007	3.502	2.413	2.135	1.907
" " " " 2.0% "	6.325	5.681	4.978	3.447	3.053	2.730	5.013	4.490	3.924	2.704	2.392	2.137

Table 19. Comparative rates of return in mechanical threshing and sun drying system, compared to traditional threshing and cleaning combined with sun drying by region, Philippines, 1975-77.

Region and Postharvest System	Cash Wage	Wage In-kind
	percent	
Mechanical threshing with sun drying		
Central Luzon	121.042	191.492
Bicol Region	183.309	191.456
Threshing frame and wooden winnower with sun drying		
Bicol Region	7.206	6.283

Table 20. Net present values (₱/100 MT) of mechanized threshing and sun drying system at alternative added wage rates, price premium and rates of interest by region, Philippines, 1975-77.

Discount Rate	Axial-Flow Thresher and Sun Drying			
	Central Luzon		Bicol Region	
	Cash Wage	Wage in-kind	Cash Wage	Wage in-kind
	(₱/100 MT)			
5	43,708	73,306	60,659	63,634
8	34,083	57,603	47,632	49,996
12	25,448	43,488	35,927	37,740
25	12,293	21,948	18,072	19,042
30	9,857	17,965	14,770	15,585
35	8,065	15,039	12,344	13,045

Table 21. Comparative ratios of mechanical threshing and sun drying by region, Philippines, 1975-77.

Discount	Cash Wage		Wage in-kind	
	Central Luzon	Bicol Region	Central Luzon	Bicol Region
5	6.477	10.474	10.185	10.939
8	5.875	9.418	9.239	9.836
12	5.203	8.265	8.182	8.631
25	3.690	5.750	5.804	6.005
30	3.291	5.103	5.176	5.329
35	2.960	4.571	4.655	4.773

Table 22. Comparative rates of return in traditional threshing and cleaning combined with mechanical drying by region, Philippines, 1975-77.

Alternative Wage Rate and Price Premium	Central Luzon[1]	Bicol Region[2]
	percent	
Cash wage and no premium	not feasible	
" " " 0.5% "	not feasible	
" " " 1.0% "	-1.618	14.663
" " " 1.5% "	23.412	32.074
" " " 2.0% "	43.640	47.527
Wage in-kind and no premium	not feasible	
" " " 0.5% "	not feasible	-37.131
" " " 1.0% "	-1.601	16.236
" " " 1.5% "	23.425	16.236
" " " 2.0% "	43.651	48.764

[1]Traditional system of threshing and cleaning is with the use of threshing frame and winnowing basket.

[2]Traditional system consist of using flail or stick and wooden winnower for cleaning.

Positive comparative net present values for this alternative are obtained only at 5 and 8 percent interest rates with quality premium of 1.2 percent or more. At 12 percent opportunity cost of capital, the price premium has to be increased to 1.4 percent to obtain a positive NPV and at 35 percent, a 2 percent premium for quality is required (Appendix F-1). The same quality premiums are needed to bring the comparative benefit-cost ratio for the incremental investment in mechanical dryers beyond the break-even point (Appendix F-2).

Alternative 4 Traditional Threshing and Cleaning Using Frame and Wooden Winnower Combined with Mechanical Drying, Bicol

A quality premium of 1.0 percent is needed for this alternative system to show a positive CRR of 14.7 percent when labor is paid in cash or 16.2 percent when labor is paid at current harvester-thresher's fee (Table 22).

The alternative is not feasible when no premium payment is considered, even with premium payment of 0.5 percent, a negative CRR was obtained in cases where labor is paid in-kind, and was not feasible in cases where labor was paid at current wages.

Alternative 5 Traditional Threshing and Cleaning Using Flail and Wooden Winnower Combined with Mechanical Drying, Bicol

Due to the high capital outlay and operating costs required in mechanical dryers, this alternative required a price premium of at least 1.5 percent to obtain a CRR of 4 percent whether labor is paid at prevailing wages or at thresher's fee (Table 23).

When price premium was at 1.0 percent, the CRR was negative and anything lower than 1.0 percent was not feasible.

Table 23. Comparative rates of return in traditional threshing using flail and/or stick with wooden winnower combined with mechanical drying, Bicol Region, Philippines, 1975-77.

Alternative Wage Rate and Price Premium	Bicol Region
Cash wage and no premium	not feasible
" " " 0.5% "	not feasible
" " " 1.0% "	-16.25
" " " 1.5% "	4.153
" " " 2.0% "	23.486
Wage in-kind and no premium	not feasible
" " " 0.5% "	not feasible
" " " 1.0% "	-16.25
" " " 1.5% "	4.279
" " " 2.0% "	23.486

In terms of net present value, only premiums of 2 percent or over resulted in positive net present values of cash flow at 5 and 8 percent interest. At higher interest rates from 25 percent on, even a 2 percent hike in premium resulted in a negative NPV (Appendix F-3).

Alternative 6 Traditional Threshing and Cleaning Using Frame and Wooden Winnower Combined with Sun Drying, Bicol

This traditional system, practiced in Bicol, resulted in a CRR of 7 percent when labor was paid in cash and 6 percent when labor was paid as a percent share of the gross harvest (Table 19).

Positive net present values were exhibited by the system at rates of interest from 8 to 35 percent both in cases where labor is paid in cash and in-kind. A 5 percent rate of interest, negative net present values were obtained (Appendix F-4).

Comparative Performance of Alternative Post-Production Systems

Among the different systems considered in the comparative analyses, the alternative using the axial-flow thresher combined with sun drying exhibited the highest CRR in spite of the foregone quality price premiums under this system. The low capital and operating costs of traditional sun drying coupled with the efficient performance of the axial-flow thresher, in terms of capacity utilization and low labor requirement, all contributed to this high CRR.

Next in rank according to CRR value is the fully mechanized system using the axial-flow thresher and the batch dryer. The mixed system where traditional methods of threshing and cleaning are combined with the mechanical dryer shows relatively low comparative rate of return even with substantial quality premiums to farmers. This is due to the high capital outlay and operating expenses required for mechanical drying such that a price premium of about 2 percent for each 5 percent in head rice yield is needed in order for the incremental investment to pay off. It was observed that the potential capacity of the mechanical dryers was not fully achieved during the implementation of the project and this contributed further to the low CRR of traditional threshing and mechanical drying.

For all postharvest systems, higher CRR's were obtained when cost of labor was imputed from the prevailing harvester and thresher share. This is because wages actually paid in rice harvesting and threshing are significantly higher than the legal agricultural wages, reflecting seasonal shortages of labor during the peak harvesting and threshing months as well as social and cultural mores at the barrio level.

The findings of the study are consistent with the greater popularity of axial-flow threshers than batch dryers in the study areas. In addition to time, labor and cost differentials, farmers claim that mechanical threshers permit easy monitoring of threshing and distribution of the final product. Unlike the traditional system which offers considerable opportunity for pilferage by those performing the threshing task, mechanical threshing effectively consolidates control of the threshing operation since the grain is simultaneously threshed, cleaned and bagged. It also facilitates handling of non-shattering varieties which is a big problem to farmers using manual methods. Moreover, the machine can also thresh high moisture paddy which comes in very handy during the wet season harvest when early completion of the different postharvest tasks is a must to save as much of the grain as possible from deterioration.

The popularity of mechanical threshers is indicative of the felt need for mechanization resulting from seasonal demands for labor during harvest, because in spite of the apparent presence of surplus labor during the rest of the season, labor bottlenecks still exist during the harvest period.

Promoting the use of the twin-bed batch dryer may continue to prove difficult because farmers believe solar drying is still the most economical if not the best method of drying. Only under conditions wherein sun drying is rendered impossible (due to inclement weather and other unfavorable circumstances) does mechanical drying become the sole recourse. Part of the problem is the high initial cost of the machine which is beyond the reach of ordinary farmers. This is further aggravated by the high operating and maintenance expenses especially the rising price of fuel. One way to offset this is through price premiums which are high enough to pay for the added cost of improved drying; however, measures and prices are not standardized and do not often reflect moisture content, percent head rice and other characteristics of the product. According to Mears (40) ... "In general, variety and appearance characteristics have the most important influence on price. The percentage of head rice is positively correlated to price but much less important than in the world markets." He concluded by saying ... "expensive mechanical driers can not be justified by the premium expected domestically for the resulting improved quality, since domestic markets provide but a small premium for reduction in broken grains. Such investment must be justified either on its advantage in preventing loss to rainy season harvests or by premiums in the world market for better quality rice."

An examination of the paddy marketing system following the field level post-production operations may likewise explain why mechanical dryers are not attractive to farmers. Figure 10 shows the distribution of paddy among recipients following harvest. Of the 60 percent retained by a tenant-operator, 25 percent is sold and 32 percent is stored for home consumption. Figure 11 pinpoints the location within the post-production distributive system where drying takes place. For tenant farmers, 52 percent of the paddy is sold or distributed before it is dried. The remainder is not sufficient inducement for an individual farmer to own and operate a mechanical dryer. While the bulk of paddy is sun-dried at the farm level and retained for household consumption, a significant share enters the market prior to drying. Under this system, all the wet paddy is collected by those involved in the market chain although, through price discounting the cost is passed back to the farmers. This is illustrated by the results of the comprehensive survey conducted in 1974-75 in Central Luzon, Southern Tagalog and Bicol region (16) which show the selling margins based on moisture content. "A mark-up in price as well as a difference in weight between dry and wet paddy at the time of sale was reported by 24 percent of those farmers trading paddy. The price margin between dry and wet paddy ranged from ₱0.02 to ₱0.25 per kilogram. Some farmers reported a price margin as high as ₱0.70 per kilogram (Table 24). On a per cavan basis,[11] the price ranged from ₱1.00 to ₱4.00 with one farmer reporting a mark-up as high as ₱13.00 per cavan. A difference in weight between wet and dry paddy on a per cavan basis was likewise reported. A cavan of wet paddy is 2 to 4 kilograms heavier than dry paddy."

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[11]A cavan weighs about 50 kilos.

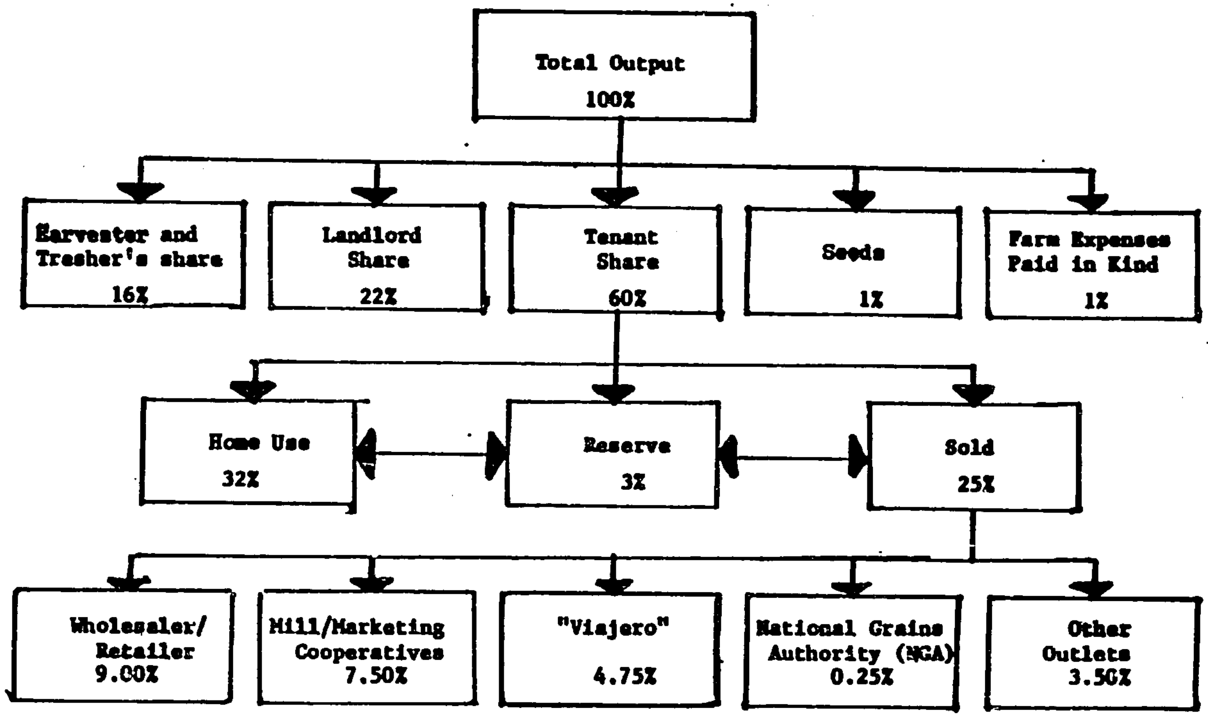

Figure 10. Production and disposal of paddy by a tenant-operator, Central Luzon, 1974-75.

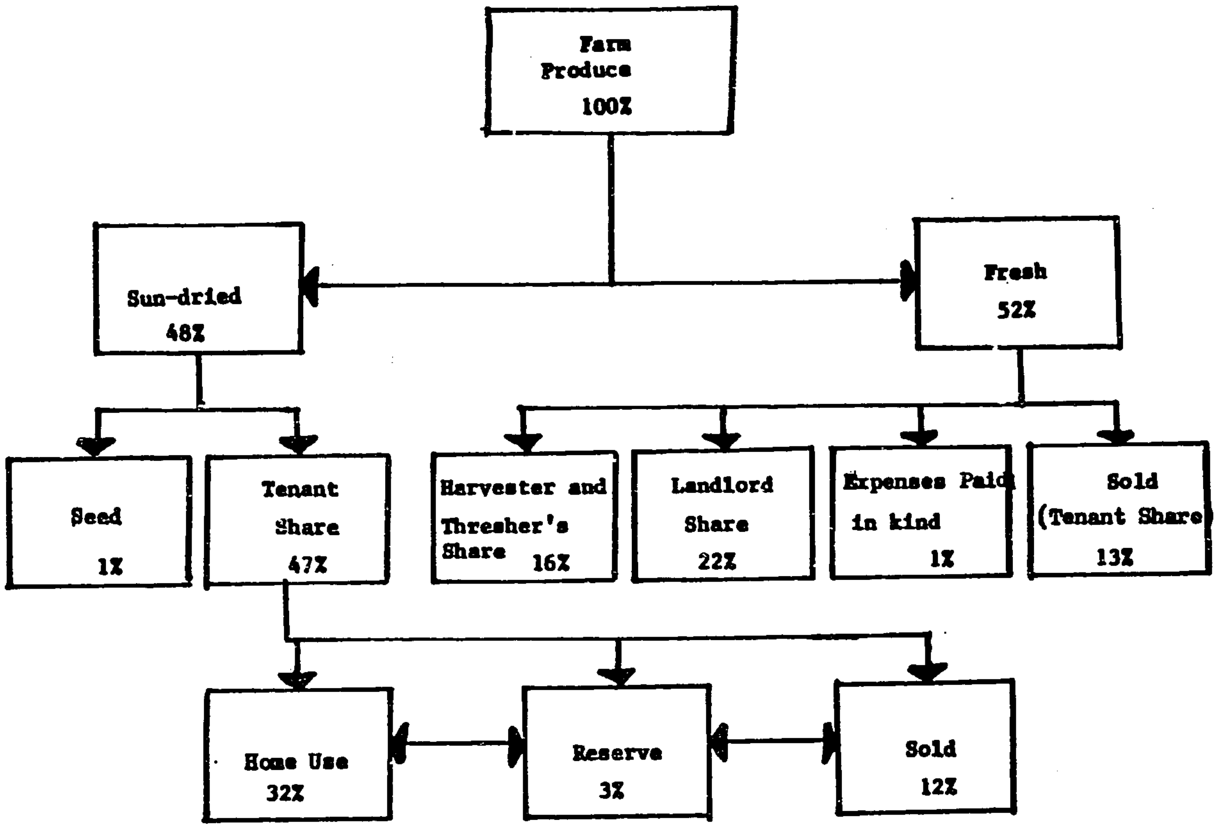

Figure 11. Flow of paddy harvest in fresh and dried form, Central L[illegible], 1974-1975.

In spite of these price and weight differentials, only 39 percent of the 403 trading farmers dry their paddy during the wet season and only 30 percent of the 293 farmers during the dry season. Three reasons were cited for this situation: a) immediate need for cash, b) commitment of produce before the date of harvest by farmers who borrowed from their landlords or merchants, and c) farmers felt the difference in price would not compensate for the time and money spent in drying, although they had no clear perception of the costs of mechanical drying if it were available.

The very low number of farmers in the survey who dried paddy prior to sale in both the wet and dry season indicates: a) lack of suitable low cost technology to carry out drying at the farm level or b) a lack of perception on the part of the farmer of the benefits to be derived from drying prior to sale. The lack of suitable buying standards which clearly outlines the increased returns a farmer may derive from selling low-moisture high quality grain also severely inhibits implementation of a drying program.

Table 24. Comparative weight and price margins between wet and dry paddy by region, 1973.

Item	Central Luzon	Southern Luzon	Camarines Sur	All
Farmers engaged in trading	149	121	137	407
		percent reporting		
Price margin per kilogram (pesos)				
0.02 - 0.25	91	75	93	90
0.26 - 0.50	6	25	7	8
0.51 - 0.70	3	-	-	2
Sub-total	34	9	24	26
Price margin per cavan (pesos)				
1.00 - 2.00	22	38	29	30
3.00 - 4.00	45	22	33	33
5.00 - 6.00	29	31	25	29
10.00 -13.00	4	9	13	8
Sub-total	29	75	40	42
Weight margin per cavan (kilograms)				
2.0	7	29	35	20
3.0	4	29	24	14
4.0	70	-	12	41
5.0	19	42	29	25
Sub-total	29	16	29	26
Weight and price margin per cavan of paddy weight margin - 2 to 4 kg. price margin - 1 to 5	100	-	100	100
Sub-total	8	-	7	6
TOTAL	100	100	100	100

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Findings

This study attempts to examine the different issues involved in the choice among alternative post-production technologies. The study has four objectives: a) to review the range of alternative post-production technologies currently practiced in the area, b) to examine the nature, patterns, magnitudes and causes of losses under various systems of post-production technology and management, c) to determine the factors that explain the choice of technology in rice post production, and d) to analyze the policy implications of these considerations.

The data used in the study are based on a series of field level trials conducted by the Department of Agricultural Engineering of the International Rice Research Institute in Central Luzon in 1975-76 and in the Bicol Regions in 1976-77. These field trials were carried out to assess the performance of the IRRI-designed axial-flow thresher and twin-bed batch dryer as compared to traditional methods of threshing, cleaning and drying.

The first part of the study examined the nature and characteristics of post-production practices in the Philippines and compared resource use and institutional arrangements embodied in each element of these systems. Then the criteria of choice of alternative technology were evaluated in terms of efficiency, factor intensity, and complexity.

Efficiency of alternative technologies was examined in terms of the performance of alternative systems in terms of (a) physical and quality losses, (b) labor and capital requirement, and (c) comparative rate of return on alternative investments. The latter two criteria were used to evaluate the factor intensity of alternative systems.

Results from the study showed that improved post-production technology involving the use of the axial-flow thresher and twin-bed batch dryer incurred lesser physical losses in the different post-production tasks compared to the traditional system. In terms of quality deterioration, significantly higher percentage head rice recovery was obtained from systems performing the different post-production tasks on time and those using mechanical dryers. In the threshing operation, the axial-flow thresher and the threshing frame (hampasan) exhibited higher percent head rice than the flail and/or stick with the mechanical thresher exhibiting a little edge over the threshing frame.

Traditional systems are more labor-intensive requiring two to three times more man-hours than the mechanized system. On the other hand, mechanized system are more capital-intensive requiring capital outlay way beyond the financial capability of small rice farmers.

General Linear Model of the Statistical Analysis System was used to determine the loss response functions for threshing loss, head rice recovery, total milling yield and market grade of milled rice among alternative post-production systems. Inferior quality characteristics of paddy and milled rice such as impurity, cracked, damaged, fermented, and chalky kernels were found to be associated with a significant reduction in the quantity, quality and market grade of milled rice.

Timeliness in the performance of subsequent post-production tasks as well as the type of machine or equipment used likewise influenced variability in rice recovery and grade. Delays in the performance of the different post-production tasks expose the grain to weather hazards resulting in kernel deterioration and possible fissuring or sun-checking, thus reducing the amount of head rice and lowering the grade of paddy and milled rice.

Comparative rate of return (CRR) on added capital investment was used to measure the economic potential of alternative post-production systems over that of the traditional systems currently practiced in the area. Among the different systems considered, the alternative combining mechanical threshing with sun drying exhibited the highest CRR in spite of the foregone quality price premiums under this system. This is due to the low capital and operating costs of sun drying coupled with the efficient performance of the axial-flow thresher.

The second highest CRR calue was obtained from systems using the axial-flow thresher and the twin-bed batch dryer. Alternatives where traditional methods of threshing and cleaning are combined with the mechanical dryer shows relatively low comparative rate of return even with substantial quality premiums to farmers. This is due to the high capital outlay and operating expenses required for mechanical drying such that a price premium of about 2 percent for each 5 percent in head rice yield is needed in order for the incremental investment to pay off. It was observed that the potential capacity of the mechanical dryers was not fully achieved during the implementation of the project and this contributed further to the low CRR of traditional threshing and mechanical drying.

For all postharvest systems, higher CRR's were obtained when cost of labor was imputed from the prevailing harvester and threshers share. This is because wages actually paid in rice harvesting and threshing are significantly higher than the legal agricultural wages, reflecting seasonal shortages of labor during the peak harvesting and threshing months as well as social and cultural mores at the barrio level.

Other institutional factors provide the general matrix for decision and choice among alternative post-production systems. These include the physical, institutional, social, cultural, technical, economic and political factors not explicitly accounted for in the empirical analyses.

Implications of the Study

With higher cropping intensity due to the new rice technology, timeliness of operations is imperative and possible only when labor is supplemented by machines. The increasing popularity of the axial-flow threshers in the study area supports this fact. Wider adoption of mechanical threshers is indicative of the felt need for mechanization resulting from seasonal demands for labor during harvests, because in spite of the apparent presence of surplus labor during the rest of the season, labor bottlenecks still exist during the harvest period.

This labor shortage is due largely to expanded irrigation which facilitates increased cropping intensity of the high-yielding rice varieties. This phenomenon has led to rapid adoption of mechanical threshers which shortens the turnaround period and permits near-optimal timing of the planting of a second crop. In addition to time, labor and cost differentials, farmers claim that unlike the traditional system which offers considerable opportunity for pilferage by those performing the threshing task, mechanical threshing effectively consolidates control of the threshing operation since the grain is simultaneously threshed, cleaned and bagged. It also facilitates handling of non-shattering varieties which is a big problem to farmers using manual methods. Moreover, the machine can also thresh high moisture paddy which comes in very handy during the wet season harvest when early completion of the different postharvest tasks is a must to save as much of the grain as possible from deterioration.

Increased thresher adoption strengthens the notion that institutional arrangements associated with traditional technologies need not be regarded as formidable obstacles to appropriate levels of mechanization. It is also indicative of the potential for local manufacture and development of simple, inexpensive postharvest equipment and the resulting favorable employment generation effects.

In the case of the batch dryer, promoting its use may continue to prove difficult because farmers believe solar drying is still the most economical if not the best method of drying. Part of the problem is the high initial cost of the machine which is beyond the reach of ordinary farmers, and the only way to offset this is through price premiums which are high enough to pay for the added cost of improved drying. Until the consumer market pays a premium for high quality paddy and milled rice, there will be no incentive for farmers to exercise care and be quality conscious in their post-production practices. In like manner, millers and other sectors in the processing and distribution chain will not be encouraged to improve their milling and processing practices if grading and quality standardization of paddy and milled rice entering the commercial market are not uniformly practiced and premium quality adequately compensated.

The reluctance to use mechanical dryers is also indicative of the fact that most small farmers have rice output too small to justify ownership or even the use of expensive equipment. There are two possible solution to this problem. One is for the farmers to form small groups or cooperatives, thus gaining enough capital and volume to be able to purchase the drying equipment. The other is for either the commercial buyers or government-owned warehouses to perform custom drying of the many small lots of grain from the farmers in the surrounding area.

Conclusions

Although the strict validity of the estimate is restricted to Central Luzon and Bicol Region, the findings of the study permit some general conclusions about alternative post-production systems in other regions:

1. Every step in the post-production chain can contribute to physical loss and quality deterioration. Paddy milling is just one of the links in the total system of post production. Its performance greatly depends on the operations preceeding it.
2. Timeliness in alternative post-production tasks is a critical factor conditioning grain loss and quality deterioration. Cultural practices must be changed to shorten the period from harvesting to milling because results from the study indicate that delays result in significant reduction in the quantity and quality of milled rice.
3. Reduction in post-production losses will require substantial adjustments in the current traditional practices. Intermediate post-production machines like threshers and dryers

show great potential. And in view of the complexity and interdependency of operations, modification in more than one element of the system is required to achieve maximum benefits from these changes.

4. The social and economic implications of using mechanical post-production equipment lies in the determination of the right type, reasonable capital outlay and optimum machine capacity that will match the needs and financial capabilities of rice farmers.

5. The farmer should be the focal point of activities since it is he who makes the production decisions, and much of the success or failure of the national effort to reduce post-production losses in rice depends upon him. The degree of efficiency of the marketing systems available to the farmer or other sectors in the rice industry determine to a significant degree the total effective food supply for the country.

6. Price support and stabilization programs for rice have to be viewed in the light of problems concerning the distribution of rice as conditioned by the geographic segmentation of the country, poor transportation facilities in many regions, and the lack of effective marketing organization for the farmers. In marketing, the critical considerations are long range in nature, including development of improved infrastructure, provision of supervised credit, effective and practical standardization of paddy and milled rice, provision of sufficient price incentives and subsidies, etc. that will enable the farmers and other sectors in the

rice industry to venture profitably into improved post-production and processing practices.

APPENDIX A

RESPONSIBILITIES OF FARMERS' ASSOCIATION AND FARMER COOPERATORS IN FIELD LEVEL TRIALS

Appendix A-1. Responsibilities of Farmers' Association

1) The farmer association must be willing to acquire and use one thresher and one twin-bed batch dryer under supervision from the IRRI personnel who will provide training to operators and technicians during the duration of the field trials.

2) The association is responsible for the up-to-date repayment of the loan used to procure the thresher and dryer; as such it should look into the proper and full utilization of the machine.

3) The association should assign at least three (3) operators for the thresher and two (2) for the dryer.

4) In addition to the regular operators, at least two elders from the association should closely supervise the operation and maintenance of the machine.

5) One elder will be assigned to the thresher and the other to the dryer with the following responsibilities:

   - to see to it that fuel and oil is always available to ensure continuous and effective use of the machine;
   - to regularly check the condition of the machine before and after use;
   - to maintain up-to-date and comprehensive record of machine utilization, e.g. a record of the expenses, receipts, no. of bags threshed and/or dried, name of the operator, etc.
   - to collect the threshing and/or drying fees immediately following operation to ensure timely collection and repayment;
   - to schedule the use of the machine so as not to impair the experiment and avoid conflicts among farmer-users especially during peak use;
   - to look into the timely delivery of the machine to the farmer's field and to ensure the safekeeping of the machines;
   - to bring to the attention of the association or the IRRI team as the case may be, any problem that may arise regarding use of the machine.

Appendix A-2. Participation Required from Farmer Cooperators

1) Full cooperation and whole-hearted support for the success of the experiment is requested from all cooperators.

2) Cooperators will be requested to assist the IRRI team in planning the different postharvest operations by providing the best estimates of harvesting dates for all plots included in the field trials.

3) Cooperators should allow supervised handling and measurement of the portion of their crop used in the trials up to and including milling.

4) Should there be any change or alterations in the date of harvesting as estimated by the farmer due to environmental as well as physical factors, this should be brought to the attention of the IRRI postharvest team as soon as possible to ensure success of the experiment.

5) Though the IRRI team will be in the area to supervise and help in the implementation of the trials, farmer cooperators are requested to assist in performing the different postharvest tasks as usual (except the use of machines in some of the systems) as if no experiment is being conducted. This will help reduce some of the possible bias that might result from the field trials.

6) For an accurate measurement of the handling losses, it is requested that the harvester-thresher's share from plots included in the experiment be taken from other plots not included in the trials. The volume of paddy included in the trials should be kept intact or remain untouched from harvesting up to drying or until all pertinent data have been recorded.

7) In the drying operation, especially with the use of the batch dryer, cooperators are requested to comply with the drying requirement even if they feel the price offered for dried paddy does not compensate for the cost of drying.

8) In the case of solar drying, cooperators are likewise requested to have their paddy sun-dried even if they need to sell their paddy immediately. This will enable IRRI staff to have complete comparative data from both traditional and improved system.

9) The number of harvesters and threshers a farmer cooperator normally employs for postharvest operations will not be limited; however, it is requested that the different operations be planned and executed in such a way as to enable the limited number of IRRI staff to record all the operations.

APPENDIX B

VARIABLES USED IN THE MULTIPLE REGRESSION ANALYSIS

<u>Quantitative Analysis</u>

Model ($Y = X_1, X_2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots X_{19}$)

<u>where</u>:

Y = amount of paddy lost per hectare (kilograms per hectare)

X_1 = threshing yield (kilograms)

X_2 = plot size (square meters)

X_3 = harvest yield (kilograms)

X_4 = labor requirement for harvesting (hours)

X_5 = " " " threshing "

X_6 = " " " drying "

X_7 = elapsed time from harvesting to threshing (hours)

X_8 = " " " threshing to drying "

X_9 = total elapsed time from harvesting to drying (hours)

X_{10} = maturity

X_{11} = yield performance

X_{12} = lodging

X_{13} = shattering

X_{14} = tillering

X_{15} = weed problem

X_{16} = pests and diseases

X_{17} = weather during harvesting

X_{18} = weather during threshing

X_{19} = weather during drying

For variables X_{10} to X_{19}, dummy values were used. For the different varietal characteristics, the <u>IRRI Standard Evaluation System for Rice</u> prepared by the International Rice Testing Program (IRTP) was used for the different scales used:

<u>Maturity</u> = is the number of days from seeding to grain ripening and for different varieties used in the trials, the following are their respective maturity days:

Variety	Maturity (days)
IR 20	120
IR 26	130
IR 30	110
IR 579-48	115
IR 747-B2-63	105
IR 1561-228-33	115
IR 1529-680	125
C4-G	125

<u>Yield performance</u> = estimated yield performance per hectare of IRRI varieties as observed from field experiment and trials in farmers field.

<u>Lodging</u> = tendency of the rice plant to droop or fall down to the ground at maturity. For lodging, the following scales were used:

<u>Scale</u> 1 - no lodging
3 - most plants (more than 50%) slightly lodged
5 - most plants moderately lodged
7 - most plants nearly flat
9 - all plants flat on the ground

<u>Shattering (Threshability)</u> = ease or difficulty of separating the grain from the panicle.

<u>Scale</u> 1 - very tight (less than 1%)
3 - tight (up to 5%)
5 - intermediate (5 to 25%)
7 - loose (25-50%)
9 - free shattering (greater than 50%)

<u>Tillering</u> = capability of rice varieties to produce tillers

<u>Scale</u> 1 - excellent, very prolific
3 - good
5 - medium
7 - poor
9 - very poor

For the different rice varieties planted and used in the village level field trials, the following scale values were used:

Variety	Lodging	Threshability	Tillering	Yield (tons/
IR 20	5	3	3	5
IR 26	3	5	3	1
IR 30	3	3	3	3
IR 579-48	1	5	3	3
IR 747-B2-63	3	7	3	5
IR 1561-228-33	3	5	3	3
IR 1529-680	1	3	3	3
C-4-G	7	7	5	7

Weed problem = presence or absence of weeds in the farmer's field. The values used for this variable are as follows:

0 - no weed problem
1 - with weed problem

Pests and Diseases = presence or absence of diseases and other pest infestation in the farmer's field.

0 - no pest or disease problem
1 - with pest or disease problem

Weather (during the performance of the different post-production operations). For this variable the following dummy values were used:

1 - good weather
2 - slight shower
3 - rain
4 - typhoon

$$\text{Loss per hectare } (Y) = \frac{\text{harvest yield } (X_3) - \text{threshing yield } (X_1)}{\text{Plot size } (X_2)} \times 10{,}000$$

where: harvest yield (X_3) = potential yield based on crop cut samples corrected for moisture content and impurities

threshing yield (X_1) = weight of paddy recovered after threshing operation corrected for moisture content and impurities

plot size = area of plot included in the field trials

Qualitative Analysis

Model ($Y = X_1, X_2, \ldots\ldots\ldots\ldots X_{13}$)

Y = can either be milling recovery (X_{13}) or head rice recovery (X_1) or brokens (X_7)

X_2 = moisture content

X_3 = chaff

X_4 = weed seed

X_5 = cracked kernels

X_6 = other varieties

X_7 = brokens

X_8 = brewer's rice or "binlid

X_9 = fermented kernels

X_{10} = damaged kernels

X_{11} = chalky kernels

X_{12} = red rice

X_{13} = milling recovery

All of the above qualitative characteristics of paddy and milled rice are expressed in percentages.

$$\text{\% Dockage} = \frac{\text{wt. of impurities}}{\text{wt. of sample}^{a}} \times 100^{1}$$

$$\text{\% Weed and Crop Seeds} = \frac{\text{wt. of weeds and crop seeds}}{\text{wt. of sample}} \times 100$$

$$\text{\% Other varieties} = \frac{\text{wt. of other varieties}}{\text{wt. of sample used}^{b}} \times 100$$

$$\text{\% Chalky and immature} = \frac{\text{wt. of chalky and immature kernels}}{\text{wt. of sample used}}$$

$$\text{\% Damaged kernel} = \frac{\text{wt. of damaged kernels}}{\text{wt. of sample used}} \times 100$$

$$\text{\% Yellow and fermented} = \frac{\text{wt. of yellow and fermented kernels}}{\text{wt. of sampled used}} \times 100$$

[1] Dockage (impurities) includes $X_3 + X_4$

$$\% \text{ Red Rice} = \frac{\text{wt. of red rice}}{\text{wt. of sample used}} \times 100$$

$$\% \text{ Milling Recovery} = \frac{\text{wt. of milled rice obtained}}{\text{wt. of paddy sample used in hulling}} \times 100$$

$$\% \text{ Head Rice} = \frac{\text{wt. of whole milled rice}}{\text{wt. of milled rice sample used}^{c}} \times 100$$

$$\% \text{ Broken Rice} = \frac{\text{wt. of broken milled rice}}{\text{wt. of milled rice sample used}} \times 100$$

$$\% \text{ Brewers Rice} = \frac{\text{wt. of brewers rice}}{\text{wt. of milled rice sample used}} \times 10$$

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[a] weight of sample = 500 g

[b] weight of sample = 25 g

[c] weight of milled rice sample used = 100 g

APPENDIX C

LABORATORY ANALYSIS OF PADDY AND MILLED RICE IN ALTERNATIVE POST-PRODUCTION SYSTEMS

1. For Paddy Samples

Field Sample
↓
Purity Analysis
↓
Cracked Kernel Determination
↓
Moisture Content Determination
↓
Dry (13 - 14% MC)
↓
Dehull 200 gram Sample
↓
Brown Rice
→ Obtain 25 grams for the analysis of:

a. Fermented & heat damaged

b. Immature Kernel

c. Red Rice

d. Other Variety

Whitening
→ Bran
→ Milled Rice

Grading

a. Head Rice

b. Broken Rice

c. Brewer's Rice

d. Milling Degree

(cont.)

2. For Milled Rice Samples

Field Sample

100 grams

Analyze for:

a. Milling degree

b. No. of paddy/100 grams

c. Head Rice

d. Brewer's Rice

25 grams for the analysis of:

a. Chalky and Immature Kernels

b. Yellow and Damaged Kernels

c. Red Rice

d. Other Variety

e. Foreign Matter

APPENDIX D

LOSS RESPONSE FUNCTIONS FOR RICE RECOVERY AND NUMERICAL GRADES OF MILLED RICE

APPENDIX TABLE D-1. RELATIONSHIP BETWEEN THLOSS AND QLTY-QTY FACTORS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: THLOSS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	12	27448229.04128711	2287352.42010726	5.90	0.0001	0.234677	83.2402
ERROR	231	89513476.89835844	387504.22899722		STD DEV		THLOSS MEAN
CORRECTED TOTAL	243	116961705.93964555			622.49837670		747.83353857

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
THRESH	1	2015586.14712879	5.20	0.0235	1	1404811.61251592	3.63	0.0582
CLEAN	1	2266841.04336389	5.85	0.0164	1	1157411.45179006	2.99	0.0853
PLTSIZE	1	5883280.96980425	15.18	0.0001	1	4823899.74051317	12.45	0.0005
REGION	1	1353089.07974213	3.49	0.0629	1	22828.65730544	0.06	0.8084
MCHVHA	1	1733981.36968659	4.47	0.0355	1	2213248.51285738	5.71	0.0177
ETHV	1	1778450.07027410	4.59	0.0332	1	280820.85351426	0.72	0.3955
ETTH	1	1167358.32832388	3.01	0.0840	1	491668.75117639	1.27	0.2612
ETHVTH	1	2281273.85506781	5.89	0.0160	1	3108212.49175866	8.02	0.0050
BROKENS	1	6611244.22672366	17.06	0.0001	1	3675861.32224308	9.49	0.0023
IMPURITY	1	333808.49206761	0.86	0.3543	1	519158.05153398	1.34	0.2483
THRHBROK	1	1026388.15545210	2.65	0.1050	1	1287063.71219955	3.32	0.0697
THRHIMPU	1	996927.30365192	2.57	0.1101	1	996927.30365192	2.57	0.1101

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	299.16071220	0.89	0.3746	336.26241691
THRESH	273.78847970	1.90	0.0582	143.79518676
CLEAN	-156.61406457	-1.73	0.0853	90.62021674
PLTSIZE	0.16663157	3.53	0.0005	0.04722765
REGION	24.42090560	0.24	0.8084	100.61432171
MCHVHA	-39.31690350	-2.39	0.0177	16.45138399
ETHV	-0.03479649	-0.85	0.3955	0.04087511
ETTH	-0.03020282	-1.13	0.2612	0.02681325
ETHVTH	3.3762524E-05	2.83	0.0050	0.00001192
BROKENS	28.81598441	3.08	0.0023	9.35604118
IMPURITY	36.96301326	1.16	0.2483	31.93418187
THRHBROK	-7.17178337	-1.82	0.0697	3.93518689
THRHIMPU	-23.93806005	-1.60	0.1101	14.92435016

APPENDIX TABLE D-2. RELATIONSHIP BETWEEN PERCENT HEADRICE AND QLTY-QTY FACTORS IN THRESHING

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: HEADRICE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	16	16711.56965338	1044.47310334	6.40	0.0001	0.310060	16.4352
ERROR	228	37186.20526907	163.09740907		STD DEV		HEADRICE MEAN
CORRECTED TOTAL	244	53897.77892245			12.77095560		77.70510204

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
CRACKK	1	3216.54218643	19.72	0.0001	1	1702.01333951	10.44	0.0014
DAMAGEK	1	1199.78023524	7.36	0.0072	1	398.14652158	2.44	0.1196
CHALKYK	1	5678.55539837	34.82	0.0001	1	4067.51804566	24.94	0.0001
FERMENTK	1	1.84630246	0.01	0.9154	1	207.15382155	1.27	0.2609
MOISTURE	1	771.87117029	4.73	0.0306	1	148.64871562	0.91	0.3408
HARVEST	1	1851.60994693	11.35	0.0009	1	22.14389640	0.14	0.7129
HANDLE	1	213.62453741	1.31	0.2536	1	204.93591943	1.26	0.2635
THRESH	1	144.90811012	0.89	0.3469	1	319.73643039	1.96	0.1628
REGION	1	227.88980222	1.40	0.2384	1	247.37608318	1.52	0.2194
MCHVHA	1	1446.43273229	8.87	0.0032	1	2.09201775	0.01	0.9099
MCTHHA	1	312.75329943	1.92	0.1675	1	290.30480827	1.78	0.1835
ETHV	1	35.18300311	0.22	0.6428	1	397.54717257	2.44	0.1199
HARVMC	1	240.65995778	1.48	0.2257	1	100.49013776	0.62	0.4333
THRHMC	1	613.78271863	3.76	0.0536	1	380.53454334	2.33	0.1280
THRHDAM	1	235.13367887	1.44	0.2311	1	241.05117707	1.48	0.2253
MDETHV	1	520.98657380	3.19	0.0752	1	520.98657380	3.19	0.0752

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	62.15408766	4.00	0.0001	15.55130018
CRACKK	-0.40685179	-3.23	0.0014	0.12594423
DAMAGEK	3.69792412	1.56	0.1196	2.36679065
CHALKYK	1.04723220	4.99	0.0001	0.20970161
FERMENTK	0.55879964	1.13	0.2609	0.49583043
MOISTURE	0.66970017	0.95	0.3408	0.70149303
HARVEST	-1.79604965	-0.37	0.7129	4.87432910
HANDLE	-1.60738877	-1.12	0.2635	1.43395466
THRESH	8.42087983	1.40	0.1628	6.01429795
REGION	-2.94644684	-1.23	0.2194	2.39245229
MCHVHA	0.07392497	0.11	0.9099	0.65272761
MCTHHA	-0.50921203	-1.33	0 835	0.38167619
ETHV	0.00221757	1.56	0.1199	0.00142064
HARVMC	0.17244778	0.78	0.4333	0.21969462
THRHMC	-0.43074961	-1.53	0.1280	0.28200133
THRHDAM	-0.99140856	-1.22	0.2253	0.81542785
MDETHV	-0.00036198	-1.79	0.0752	0.00020253

APPENDIX TABLE D-3. RELATIONSHIP BETWEEN PERCENT HEADRICE AND QLTY-QTY FACTORS IN DRYING

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: HEADRICE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	23	11463.51307375	498.41361190	6.31	0.0001	0.397570	11.0972
ERROR	220	17370.45849470	78.95662952		STD DEV		HEADRICE MEAN
CORRECTED TOTAL	243	28833.97156845			8.88575430		80.07233607

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
CHALKYK	1	113.26574844	1.43	0.2323	1	68.25050676	0.86	0.3535
IMPURITY	1	1159.62220885	14.69	0.0002	1	2.97499958	0.04	0.8463
CRACKK	1	3623.48622393	45.89	0.0001	1	771.14220294	9.77	0.0020
FERMENTK	1	2.40014510	0.03	0.8617	1	627.62900614	7.94	0.0053
DAMAGEK	1	343.12545377	4.35	0.0383	1	163.63942910	2.06	0.1521
HARVEST	1	799.87584145	10.13	0.0017	1	710.92950815	9.00	0.0030
HANDLE	1	995.20716617	12.60	0.0005	1	319.65971362	4.05	0.0454
THRESH	1	42.62428366	0.54	0.4633	1	7.76982022	0.10	0.7540
CLEAN	1	0.25094527	0.00	0.9551	1	178.91875666	2.27	0.1337
DRY	1	760.82592514	9.64	0.0022	1	21.75865271	0.28	0.6001
REGION	1	471.73214557	5.97	0.0153	1	449.04772240	5.69	0.0179
MDHVHA	1	27.71490842	0.35	0.5541	1	255.23240164	3.23	0.0736
MDDRHA	1	270.74665927	3.43	0.0654	1	100.31764519	1.27	0.2609
ETHV	1	1.06752997	0.01	0.9075	1	155.43444566	1.97	0.1620
ETDR	1	0.00325977	0.00	0.9949	1	346.04810712	4.38	0.0374
MDETHV	1	78.24812198	0.99	0.3206	1	266.85322572	3.38	0.0674
MDETDR	1	305.46996633	3.87	0.0504	1	245.51027112	3.11	0.0793
DRYFERK	1	826.60445210	10.47	0.0014	1	765.43609745	9.69	0.0021
ETTHFERK	1	104.99465769	1.33	0.2501	1	192.14105256	2.43	0.1202
DRYDAM	1	637.04787279	8.07	0.0049	1	492.91862033	6.24	0.0132
CLENIMPU	1	194.19965818	2.46	0.1182	1	178.71357524	2.26	0.1339
THRHCPAK	1	46.55483309	0.59	0.4434	1	90.27196012	1.14	0.2861
DRYCPAK	1	658.44504739	8.34	0.0043	1	658.44504739	8.34	0.0043

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	70.27910908	12.71	0.0001	5.52848002
CHALKYK	0.16712143	0.93	0.3535	0.17974127
IMPURITY	-0.12926435	-0.19	0.8463	0.66597636
CRACKK	-1.57371160	-3.13	0.0020	0.50356112
FERMENTK	-2.78315332	-2.82	0.0053	0.98761423
DAMAGEK	1.63520537	1.44	0.1521	1.13794241
HARVEST	2.38138573	3.00	0.0030	0.79361643
HANDLE	-2.06707742	-2.01	0.0454	1.02732319
THRESH	0.50389277	0.31	0.7540	1.60617270
CLEAN	-2.39413256	-1.51	0.1337	1.59043000
DRY	-0.60658586	-0.52	0.6001	1.15550160
REGION	5.56416125	2.39	0.0179	2.33317739
MDHVHA	0.78022829	1.80	0.0736	0.43395827
MDDRHA	29.68658992	1.13	0.2609	26.33657850
ETHV	0.00139385	1.40	0.1620	0.00099343
ETDR	0.00090131	2.09	0.0374	0.00043052
MDETHV	-0.00026074	-1.84	0.0674	0.00014183
MDETDR	-0.00774856	-1.76	0.0793	0.00439600
DRYFERK	0.89217134	3.11	0.0021	0.28654187
ETTHFERK	-0.00015597	-1.56	0.1202	0.00009992
DRYDAM	-0.83641667	-2.50	0.0132	0.33475949
CLENIMPU	0.31244956	1.50	0.1339	0.20765037
THRHCPAK	0.16639975	1.07	0.2861	0.15562183
DRYCRAK	0.22913698	2.89	0.0043	0.07934686

APPENDIX TABLE D-4. RELATIONSHIP BETWEEN MILL RECOVERY AND QLTY-QTY FACTORS IN THRESHING

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: MILLREC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	18	1181.41574136	65.63420785	9.19	0.0001	0.422715	3.9945
ERROR	226	1613.41243253	7.13899306		STD DEV		MILLREC MEAN
CORRECTED TOTAL	244	2794.82817389			2.67188542		66.88567347

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MOISTURE	1	32.13654207	4.50	0.0350	1	10.55919132	1.48	0.2252
CHALKYK	1	1.03121578	0.14	0.7043	1	4.96378955	0.70	0.4043
IMPURITY	1	619.25821828	86.74	0.0001	1	311.95293627	43.70	0.0001
CRACKK	1	38.38601488	5.38	0.0213	1	14.74422734	2.07	0.1521
FERMENTK	1	1.64441365	0.23	0.6317	1	5.86274066	0.82	0.3658
DAMAGEK	1	2.40200177	0.34	0.5625	1	4.43479402	0.62	0.4314
OTHERVAR	1	159.07299045	22.28	0.0001	1	171.86459398	24.07	0.0001
HARVEST	1	90.13803830	12.63	0.0005	1	49.15010195	6.89	0.0093
THRESH	1	18.33497957	2.57	0.1104	1	15.66131035	2.19	0.1400
MCTHHA	1	3.10105409	0.43	0.5105	1	34.54439529	4.84	0.0288
ETTH	1	13.08083223	1.83	0.1772	1	51.81368247	7.27	0.0076
MCETTH	1	26.18467620	3.67	0.0567	1	42.38275361	5.94	0.0156
ETTHFERK	1	9.01670054	1.26	0.2623	1	10.77771405	1.51	0.2205
CLENIMPU	1	51.03812144	7.15	0.0080	1	52.94323119	7.42	0.0070
THRHCRAK	1	35.71213965	5.00	0.0263	1	54.36089896	7.61	0.0063
THRHBROK	1	19.44570685	2.72	0.1002	1	15.32350853	2.15	0.1443
MCRACK	1	38.94423677	5.46	0.0204	1	48.64217174	6.81	0.0097
THRHMC	1	22.48785863	3.15	0.0773	1	22.48785863	3.15	0.0773

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	65.92679849	20.75	0.0001	3.17660665
MOISTURE	0.16972588	1.22	0.2252	0.13955687
CHALKYK	0.03810209	0.84	0.4043	0.04560237
IMPURITY	-0.83931955	-6.61	0.0001	0.12696191
CRACKK	-0.21562174	-1.44	0.1521	0.15003757
FERMENTK	0.16371894	0.91	0.3658	0.18060210
DAMAGEK	-0.06393522	-0.79	0.4314	0.08111887
OTHERVAR	-0.20411277	-4.91	0.0001	0.04160020
HARVEST	0.49228869	2.62	0.0093	0.18754240
THRESH	1.82849943	1.48	0.1400	1.23452322
MCTHHA	0.27991082	2.20	0.0288	0.12724753
ETTH	0.00042656	2.70	0.0076	0.00015824
MCETTH	-6.3034087E-05	-2.44	0.0156	0.00002587
ETTHFERK	-6.1679573E-05	-1.23	0.2205	0.00005020
CLENIMPU	0.13844093	2.72	0.0070	0.05083675
THRHCRAK	-0.10301272	-2.76	0.0063	0.03733069
THRHBROK	-0.00900545	-1.47	0.1443	0.00614674
MCRACK	0.01876003	2.61	0.0097	0.00718696
THRHMC	-0.10098294	-1.77	0.0773	0.05684106

APPENDIX TABLE D-5. RELATIONSHIP BETWEEN MILL RECOVERY AND QTY-QLTY FACTORS IN DRYING

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: MILLREC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	18	799.94406378	44.44133688	7.69	0.0001	0.390455	3.5835
ERROR	216	1248.59189623	5.78051804		STD DEV		MILLREC MEAN
CORRECTED TOTAL	234	2048.53596001			2.40427679		67.09200000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MOISTURE	1	11.30599825	1.96	0.1634	1	5.36333646	0.93	0.3365
CHALKYK	1	68.57145364	11.86	0.0007	1	37.99177511	6.57	0.0110
IMPURITY	1	103.99431204	17.99	0.0001	1	80.05377786	13.97	0.0002
CRACKK	1	14.79817943	2.56	0.1111	1	73.65626187	12.74	0.0004
FERMENTK	1	302.39511598	52.31	0.0001	1	35.30812332	6.11	0.0142
DAMAGEK	1	25.25819850	4.37	0.0370	1	11.42766220	1.98	0.1612
OTHERVAR	1	22.64661541	3.92	0.0490	1	10.35266503	1.79	0.1822
HARVEST	1	28.81929706	4.99	0.0265	1	4.01591774	0.69	0.4055
THRESH	1	0.97392449	0.17	0.6819	1	16.68111975	2.89	0.0908
MCTHHA	1	0.32068376	0.06	0.8140	1	4.50126088	0.78	0.3785
ETTH	1	17.43546315	3.02	0.0839	1	4.97573743	0.86	0.3544
MDETTH	1	3.33898252	0.58	0.4481	1	4.71393924	0.82	0.3675
ETTHFERK	1	0.68740908	0.12	0.7305	1	3.07835905	0.53	0.4663
CLENIMPU	1	45.50792401	7.87	0.0055	1	68.10124379	11.78	0.0007
THRHCRAK	1	59.54299350	10.30	0.0015	1	35.70474364	6.18	0.0137
THRHBROK	1	54.00390508	9.34	0.0025	1	55.06841711	9.53	0.0023
MCRACK	1	9.81184620	1.70	0.1940	1	24.22681507	4.19	0.0418
THRHMC	1	30.53176169	5.28	0.0225	1	30.53176169	5.28	0.0225

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	67.87868407	26.17	0.0001	2.59378589
MOISTURE	0.10866303	0.96	0.3365	0.11281002
CHALKYK	-0.12784919	-2.56	0.0110	0.04986468
IMPURITY	-0.63015815	-3.74	0.0002	0.16849336
CRACKK	-0.61003065	-3.57	0.0004	0.17090934
FERMENTK	0.29406355	2.47	0.0142	0.11898364
DAMAGEK	-0.16387329	-1.41	0.1612	0.11656438
OTHERVAR	-0.06564827	-1.34	0.1822	0.04905470
HARVEST	0.15732558	0.83	0.4055	0.18875194
THRESH	1.89511302	1.70	0.0908	1.11559330
MCTHHA	0.10956800	0.88	0.3785	0.12461852
ETTH	0.00012757	0.93	0.3544	0.00013745
MDETTH	-2.24864 77E-05	-0.90	0.3675	0.00002490
ETTHFERK	1.89037054E-05	0.73	0.4663	0.00002602
CLENIMPU	0.17750234	3.43	0.0007	0.05171422
THRHCRAK	0.11293698	2.49	0.0137	0.04544191
THRHBROK	-0.02234831	-3.09	0.0023	0.00724064
MCRACK	0.01431730	2.05	0.0418	0.00699353
THRHMC	-0.11423104	-2.30	0.0225	0.04973403

APPENDIX TABLE D-6. GRADE OF MILLED RICE IN THRESHING BY QTY-QLTY FACTORS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: GRADE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	14	37.66753214	2.69053801	10.64	0.0001	0.394204	26.7267
ERROR	229	57.88574655	0.25277619		STD DEV		GRADE MEAN
CORRECTED TOTAL	243	95.55327869			0.50276852		1.88114754

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MOISTURE	1	3.42947629	13.57	0.0003	1	4.84806928	19.18	0.0001
FERMENTK	1	0.96049587	3.80	0.0525	1	0.99590985	3.94	0.0483
HANDLE	1	0.66095947	2.61	0.1073	1	0.95078298	3.76	0.0537
CLEAN	1	5.78202173	22.87	0.0001	1	0.39917882	1.58	0.2102
REGION	1	22.67072991	89.69	0.0001	1	19.64244972	77.71	0.0001
MDHVHA	1	0.91370172	3.61	0.0585	1	0.01149474	0.05	0.8313
ETHV	1	0.00237621	0.01	0.9228	1	0.90325341	3.57	0.0600
ETTH	1	0.05132610	0.20	0.6527	1	0.30526569	1.21	0.2730
MATURITY	1	1.00653577	3.98	0.0472	1	0.97855909	3.87	0.0503
ETHVTH	1	0.55077959	2.18	0.1413	1	0.76047881	3.01	0.0842
MDETHV	1	0.35245341	1.39	0.2389	1	0.38074759	1.51	0.2210
HANDMC	1	1.07183640	4.24	0.0406	1	0.90022996	3.56	0.0604
HANDFERK	1	0.01652275	0.07	0.7984	1	0.02417945	0.10	0.7574
ETTHFERK	1	0.19841651	0.78	0.3766	1	0.19841651	0.78	0.3766

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	0.32672814	0.45	0.6523	0.72417971
MOISTURE	0.07732041	4.38	0.0001	0.01765541
FERMENTK	0.08411169	1.98	0.0483	0.04237546
HANDLE	-0.73764189	-1.94	0.0537	0.38034083
CLEAN	-0.04664926	-1.26	0.2102	0.03712180
REGION	-0.77816618	-8.82	0.0001	0.08827599
MDHVHA	-0.00540655	-0.21	0.8313	0.02535353
ETHV	-0.00012130	-1.89	0.0600	0.00006417
ETTH	-2.70033858E-05	-1.10	0.2730	0.00002457
MATURITY	0.01017994	1.97	0.0503	0.00517392
ETHVTH	1.64061155E-08	1.73	0.0842	0.00000001
MDETHV	9.7822314E-06	1.23	0.2210	0.00000797
HANDMC	0.03305929	1.89	0.0604	0.01751799
HANDFERK	0.00837004	0.31	0.7574	0.02706279
ETTHFERK	-8.4129828E-06	-0.89	0.3766	0.00000950

APPENDIX TABLE D-7. GRADE OF MILLED RICE IN DRYING BY QTY-QLTY FACTORS

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: GRADE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	30	54.88624936	1.82954298	9.75	0.0001	0.579789	22.4919
ERROR	212	39.78037731	0.18764329		STD DEV		GRADE MEAN
CORRECTED TOTAL	242	94.66666667			0.43317813		1.92592593

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
MOISTURE	1	7.80882009	41.62	0.0001	1	2.13041598	11.35	0.0009
CRACKK	1	0.12236285	0.65	0.4203	1	0.19485035	1.03	0.3103
FERMENTK	1	6.37604444	33.98	0.0001	1	0.04903055	0.26	0.6097
HARVEST	1	0.92566582	4.93	0.0274	1	2.30970268	12.31	0.0006
HANDLE	1	0.00000727	0.00	0.9950	1	2.64564409	14.10	0.0002
THRESH	1	1.09235354	5.82	0.0167	1	0.50310620	2.68	0.1030
DRY	1	5.43534294	28.97	0.0001	1	0.53729316	2.86	0.0921
REGION	1	12.31727370	65.64	0.0001	1	5.26539443	28.06	0.0001
MONTHS	1	1.88309981	10.04	0.0018	1	0.68622085	3.66	0.0572
MDTHNA	1	0.90505782	4.82	0.0292	1	0.00312614	0.02	0.8974
MDDPHA	1	0.50098508	2.67	0.1037	1	0.89912043	4.74	0.0306
ETHV	1	0.09927358	0.53	0.4678	1	0.56258116	3.00	0.0848
ETTH	1	0.02115776	0.11	0.7374	1	1.51471641	8.07	0.0049
FTDR	1	0.40884424	2.18	0.1414	1	1.97751977	10.54	0.0014
LCDGF	1	0.33561795	1.79	0.1825	1	0.59206490	3.16	0.0769
MATURITY	1	1.95314340	10.41	0.0015	1	1.33042983	7.09	0.0083
MCRACK	1	0.01409971	0.08	0.7843	1	0.93897802	5.00	0.0263
MCFRMENT	1	0.01219441	0.06	0.7990	1	0.93510886	4.98	0.0266
ETHVTH	1	0.63584697	3.39	0.0670	1	2.31530747	12.34	0.0005
ETHVDR	1	1.83103882	9.76	0.0020	1	1.74364407	9.29	0.0026
MDETHV	1	2.91770991	15.02	0.0001	1	2.71792088	14.48	0.0002
MDETTH	1	0.52840079	2.92	0.0948	1	0.61677392	3.29	0.0712
HARVHC	1	1.62491051	8.66	0.0036	1	2.23332317	11.90	0.0007
HANDHC	1	1.88822145	10.07	0.0017	1	2.22420030	11.85	0.0007
HARVFERK	1	0.06589974	0.37	0.5423	1	1.00500850	5.36	0.0216
FTHVFERK	1	0.64928682	3.46	0.0642	1	0.62853482	3.35	0.0686
DRYFERK	1	0.98310402	5.24	0.0231	1	1.29776634	6.92	0.0092
THRHCPAK	1	0.65165619	3.47	0.0630	1	1.07195230	5.71	0.0177
HANDCPAK	1	1.18938201	6.34	0.0126	1	2.10273500	11.21	0.0010
DRYCPAK	1	1.80494614	9.62	0.0022	1	1.80484614	9.62	0.0022

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	-0.75123956	-1.14	0.2552	0.65845286
MOISTURE	0.05254711	3.37	0.0009	0.01559492
CRACKK	-0.03306045	-1.02	0.3103	0.03251000
FERMENTK	0.04991447	0.51	0.6097	0.09763919
HARVEST	0.63093443	3.51	0.0006	0.17989437
HANDLE	-1.04911566	-3.75	0.0002	0.27939853
THRESH	0.09386190	1.64	0.1030	0.05732304
DRY	0.08631889	1.69	0.0921	0.05101134
REGION	-0.69172837	-5.30	0.0001	0.13058300
MONTHA	-0.04213932	-1.91	0.0572	0.02203547
MDTHNA	0.00321732	0.13	0.8974	0.02492620
MDDPHA	1.05119667	2.18	0.0306	0.48291439
ETHV	-0.00013845	-1.73	0.0848	0.00007996
ETTH	-0.00016234	-2.84	0.0049	0.00005714
FTDR	0.00015816	3.25	0.0014	0.00004872
LCDGF	0.03625498	1.78	0.0769	0.02039653
MATURITY	0.01399263	2.66	0.0083	0.00525121
MCRACK	0.00258434	2.24	0.0263	0.00115528
MCFRMENT	0.00810636	2.23	0.0266	0.00363129
ETHVTH	4.3281452E-08	3.51	0.0005	0.00000001
ETHVDR	-2.5944276E-08	-3.05	0.0026	0.00000001
MDETHV	2.6735864E-05	3.81	0.0002	0.00000708
MDETTH	-8.5984078E-06	-1.81	0.0712	0.00000474
HARVHC	-0.02769307	-3.45	0.0007	0.00001556
HANDHC	0.04437189	3.44	0.0007	0.01288781
HARVFERK	-0.04901563	-2.32	0.0216	0.02117119
FTHVFERK	-2.2893561E-05	-1.83	0.0686	0.00001251
DRYFERK	-0.03720483	-2.63	0.0092	0.01414680
THRHCPAK	-0.02049656	-2.39	0.0177	0.00857551
HANDCPAK	0.01788392	3.35	0.0010	0.00534241
DRYCPAK	0.01285507	3.10	0.0022	0.00414497

APPENDIX E

STANDARD GRADE REQUIREMENTS FOR PHILIPPINE MILLED RICE

Appendix Table E. Standard grade requirements for Philippine milled rice

Item	Premium Grade	Grade 1	Grade 2	Grade 3
		Per Cent		
Head Rice	95 Min.	85 Min.	75 Min.	65 Min.
Brokens	4 Max.	12 Max.	20 Max.	28 Max.
Brewer	1 Max.	3 Max.	5 Max.	7 Max.
Yellow and damaged	0.5 Max.	1 Max.	2 Max.	4 Max.
Chalky and immature	2 Max.	4 Max.	6 Max.	8 Max.
Paddy (no./100 gm)	none	1 Max.	2 Max.	3 Max.
Other varieties	2 Max.	4 Max.	6 Max.	8 Max.
Red Rice	none	0.5 Max.	1.0 Max.	1.5 Max.
Foreign matter	none	0.25 Max.	0.5 Max.	1 Max.
Moisture Content	Not greater than 14 per cent			

APPENDIX F

PROJECTED CASH FLOW AND COMPARATIVE RATES OF RETURN FOR ALTERNATIVE RICE POSTHARVEST SYSTEMS

A LISTING OF THE DATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON,PHILIPPINES

YEAR	INVESTMENT ALTERNATE	OUTLAY BASE	B A S E C A S E LABOR	REPAIRS	LOSS	A L T E R N A T I V E C A S E LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	9112.	920.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
2	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
3	0.	10.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
4	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
5	0.	100.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
6	3289.	10.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
7	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
8	4972.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
9	0.	10.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
10	0.	100.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
11	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
12	3289.	10.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
13	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
14	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
15	0.	920.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
16	4972.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
17	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
18	3289.	10.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
19	0.	0.	4130.	46.	4465.	1078.	911.	1406.	2054.	-1625.
20	-5541.	-543.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL 56.254 PERCENT

PERIOD NO.	PERIOD IDENT.	COMPARATIVE OUTLAY (P/100MT) ALTERNATIVE	COMPARATIVE OUTLAY (P/100MT) BASE CASE	COMPARATIVE OUTLAY (P/100MT) DIFFERENCE	COMPARATIVE COST** (P/100MT) BASE CASE	COMPARATIVE COST** (P/100MT) ALTERNATIVE	COMPARATIVE COST** (P/100MT) DIFFERENCE	PRESENT VALUE FACTOR	PRESENT VALUES OUTLAY	PRESENT VALUES SAVINGS
0		9112.	920.	8192.	0.	0.	0.	1.0000	8192.	0.
1		0.	0.	0.	8641.	3824.	4817.	0.6400	0.	3083.
2		0.	0.	0.	8641.	3824.	4817.	0.4096	0.	1973.
3		0.	10.	-10.	8641.	3824.	4817.	0.2621	-3.	1263.
4		0.	0.	0.	8641.	3824.	4817.	0.1678	0.	808.
5		0.	100.	-100.	8641.	3824.	4817.	0.1074	-11.	517.
6		3289.	10.	3279.	8641.	3824.	4817.	0.0687	225.	331.
7		0.	0.	0.	8641.	3824.	4817.	0.0440	0.	212.
8		4972.	0.	497[illegible]	8641.	3824.	4817.	0.0281	140.	136.
9		0.	10.	-1[illegible]	8641.	3824.	4817.	0.0180	-0.	87.
10		0.	100.	-100.	8641.	3824.	4817.	0.0115	-1.	56.
11		0.	0.	0.	8641.	3824.	4817.	0.0074	0.	36.
12		3289.	10.	3279.	8641.	3824.	4817.	0.0047	15.	23.
13		0.	0.	0.	8641.	3824.	4817.	0.0030	0.	15.
14		0.	0.	0.	8641.	3824.	4817.	0.0019	0.	9.
15		0.	920.	-920.	8641.	3824.	4817.	0.0012	-1.	6.
16		4972.	0.	4972.	8641.	3824.	4817.	0.0008	4.	4.
17		0.	0.	0.	8641.	3824.	4817.	0.0005	0.	2.
18		3289.	10.	3279.	8641.	3824.	4817.	0.0003	1.	2.
19		0.	0.	0.	8641.	3824.	4817.	0.0002	0.	1.
20		-5541.	-543.	-4998.	0.	0.	0.	0.0001	-1.	0.
	TOTAL	23382.	-1547.	21835.	164179.	72656.	91523.		8561.	8561.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100MT SAVINGS	PRESENT VALUE IN P/100MT OUTLAY	PRESENT VALUE IN P/100MT DIFFERENCE
5.000	3.427	58215.	16989.	4122[illegible].
8.000	3.078	46261.	15029.	31232.
12.000	2.697	35481.	13155.	22326.
25.000	1.867	18990.	10170.	8820.
30.000	1.654	15947.	9642.	6305.
35.000	1.479	13717.	9275.	4442.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
MECHANIZED SYSTEM INVOLVING THE AXIAL-FLOW THRESHER AND TWIN-BED BATCH DRYER COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING THE FRAME(HANPASAN), WINNOWING BASKET(BILAO) FOR CLEANING AND DRYING PADDY UNDER THE SUN.

A LISTING OF THE DATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON,PHILIPPINES

YEAR	INVESTMENT	OUTLAY	B A S E	C A S E		A L T E R N A T I V E	C A S E			
	ALTERNATE	BASE	LABOR	REPAIRS	LOSS	LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	4420.	920.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
2	0	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
3	0.	10.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
4	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
5	0.	100.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
6	3289.	10.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
7	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
8	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
9	0.	10.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
10	0.	100.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
11	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
12	3289.	10.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
13	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
14	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
15	810.	920.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
16	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
17	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
18	3289.	10.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
19	0.	0.	4130.	46.	4465.	1358.	402.	2147.	457.	0.
20	-3076.	-543.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL 121.042 PERCENT

PERIOD		COMPARATIVE OUTLAY (P/100MT)			COMPARATIVE COST** (P/100MT)			PRESENT VALUE	PRESENT VALUES	
NO.	IDENT.	ALTERNATIVE	BASE CASE	DIFFERENCE	BASE CASE	ALTERNATIVE	DIFFERENCE	FACTOR	OUTLAY	SAVINGS
0		4428.	920.	3508.	0.	0.	0.	1.0000	3508.	0.
1		0.	0.	0.	8641.	4364.	4277.	0.4524	0.	1935.
2		0.	0.	0.	8641.	4364.	4277.	0.2047	0.	875.
3		0.	10.	-10.	8641.	4364.	4277.	0.0926	-1.	396.
4		0.	0.	0.	8641.	4364.	4277.	0.0419	0.	179.
5		0.	100.	-100.	8641.	4364.	4277.	0.0190	-2.	81.
6		3289.	10.	3279.	8641.	4364.	4277.	0.0086	28.	37.
7		0.	0.	0.	8641.	4364.	4277.	0.0039	0.	17.
8		0.	0.	0.	8641.	4364.	4277.	0.0018	0.	8.
9		0.	10.	-10.	8641.	4364.	4277.	0.0008	-0.	3.
10		0.	100.	-100.	8641.	4364.	4277.	0.0004	-0.	2.
11		0.	0.	0.	8641.	4364.	4277.	0.0002	0.	1.
12		3289.	10.	3279.	8641.	4364.	4277.	0.0001	0.	0.
13		0.	0.	0.	8641.	4364.	4277.	0.0000	0.	0.
14		0.	0.	0.	8641.	4364.	4277.	0.0000	0.	0.
15		810.	920.	-110.	8641.	4364.	4277.	0.0000	-0.	0.
16		0.	0.	0.	8641.	4364.	4277.	0.0000	0.	0.
17		0.	0.	0.	8641.	4364.	4277.	0.0000	0.	0.
18		3289.	10.	3279.	8641.	4364.	4277.	0.0000	0.	0.
19		0.	0.	0.	8641.	4364.	4277.	0.0000	0.	0.
20		-3076.	-543.	-2533.	0.	0.	0.	0.0000	-0.	0.
	TOTAL	12029.	-1547.	10482.	164179.	82916.	81263.		3533.	3533.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100MT SAVINGS	OUTLAY	DIFFERENCE
5.000	6.477	51689.	7981.	43708.
8.000	5.875	41075.	6992.	34083.
12.000	5.203	31503.	6055.	25448.
25.000	3.690	16861.	4569.	12293.
30.000	3.291	14159.	4302.	9857.
35.000	2.960	12179.	4114.	8065.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:

AXIAL-FLOW THRESHING COMBINED WITH SUN-DRYING COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING THE FRAME(HAMPASAN), WINNOWING BASKET(BILAO) FOR CLEANING AND DRYING PADDY UNDER THE SUN.

A LISTING OF THE DATA

1 1 3 5 5 4 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON,PHILIPPINES

YEAR	INVESTMENT	OUTLAY	B A S E	C A S E		A L T E R N A T I V E	C A S E			
	ALTERNATE	BASE	LABOR	REPAIRS	LOSS	LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	5604.	920.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
2	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
3	10.	10.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
4	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
5	100.	100.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
6	10.	10.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
7	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
8	4792.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
9	10.	10.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
10	100.	100.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
11	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
12	10.	10.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
13	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
14	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
15	110.	920.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
16	4972.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
17	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
18	10.	10.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
19	0.	0.	4130.	46.	4465.	3850.	554.	3724.	1597.	-1625.
20	-3008.	-543.	0.	0.	0.	0.	0.	0.	0.	0.

I N V E S T M E N T   F E A S I B I L I T Y   A N A L Y S I S

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN CENTRAL LUZON,PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL -1.618 PERCENT

PERIOD NO.	IDENT.	COMPARATIVE OUTLAY (P/100MT) ALTERNATIVE	BASE CASE	DIFFERENCE	COMPARATIVE COST** (P/100MT) BASE CASE	ALTERNATIVE	DIFFERENCE	PRESENT VALUE FACTOR	PRESENT VALUES OUTLAY	SAVINGS
0		5604.	920.	4684.	0.	0.	0.	1.0000	4684.	0.
1		0.	0.	0.	8641.	8100.	541.	1.0164	0.	550.
2		0.	0.	0.	8641.	8100.	541.	1.0332	0.	559.
3		10.	10.	0.	8641.	8100.	541.	1.0501	0.	568.
4		0.	0.	0.	8641.	8100.	541.	1.0674	0.	577.
5		100.	100.	0.	8641.	8100.	541.	1.0850	0.	587.
6		10.	10.	0.	8641.	8100.	541.	1.1028	0.	597.
7		0.	0.	0.	8641.	8100.	541.	1.1209	0.	606.
8		4792.	0.	4792.	8641.	8100.	541.	1.1394	5460.	616.
9		10.	10.	0.	8641.	8100.	541.	1.1581	0.	627.
10		100.	100.	0.	8641.	8100.	541.	1.1771	0.	637.
11		0.	0.	0.	8641.	8100.	541.	1.1965	0.	647.
12		10.	10.	0.	8641.	8100.	541.	1.2162	0.	658.
13		0.	0.	0.	8641.	8100.	541.	1.2362	0.	669.
14		0.	0.	0.	8641.	8100.	541.	1.2565	0.	680.
15		110.	920.	-810.	8641.	8100.	541.	1.2771	-1034.	691.
16		4972.	0.	4972.	8641.	8100.	541.	1.2981	6454.	702.
17		0.	0.	0.	8641.	8100.	541.	1.3155	0.	714.
18		10.	10.	0.	8641.	8100.	541.	1.3412	0.	726.
19		0.	0.	0.	8641.	8100.	541.	1.3632	0.	738.
20		-3008.	-563.	-2465.	0.	0.	0.	1.3856	-3416.	0.
	TOTAL	12720.	-1547.	11173.	164179.	153900.	10279.		12148.	12148.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100MT SAVINGS	OUTLAY	DIFFERENCE
5.000	0.736	6538.	8886.	-2348.
8.000	0.654	5196.	7940.	-2744.
12.000	0.567	3985.	7027.	-3042.
25.000	0.383	2133.	5571.	-3438.
30.000	0.337	1791.	5317.	-3526.
35.000	0.299	1541.	5144.	-3604.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
TRADITIONAL THRESHING AND CLEANING COMBINED WITH BATCH DRYING COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING THE FRAME(HAMPASAN),WINNOWING BASKET(BILAO) FOR CLEANING AND DRYING PADDY UNDER THE SUN.

A LISTING OF THE CATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN BICOL REGION,PHILIPPINES

YEAR	INVESTMENT ALTERNATE	OUTLAY BASE	B A S E C A S E LABOR	REPAIRS	LOSS	A L T E R N A T I V E C A S E LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	11276.	2292.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
2	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
3	0.	91.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
4	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
5	0.	581.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
6	3363.	91.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
7	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
8	6856.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
9	0.	91.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
10	0.	581.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
11	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
12	3363.	91.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
13	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
14	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
15	0.	2292.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
16	6856.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
17	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
18	3363.	91.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
19	0.	0.	7240.	115.	3246.	1640.	1128.	837.	2940.	-1625.
20	-6738.	-1085.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN BICOL REGION, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL __61.615_ PERCENT

PERIOD NO.	PERIOD IDENT.	COMPARATIVE OUTLAY (P/100HT) ALTERNATIVE	COMPARATIVE OUTLAY (P/100HT) BASE CASE	COMPARATIVE OUTLAY (P/100HT) DIFFERENCE	COMPARATIVE COST** (P/100HT) BASE CASE	COMPARATIVE COST** (P/100HT) ALTERNATIVE	COMPARATIVE COST** (P/100HT) DIFFERENCE	PRESENT VALUE FACTOR	PRESENT VALUES OUTLAY	PRESENT VALUES SAVINGS
0		11276.	2292.	8984.	0.	0.	0.	1.0000	8984.	0.
1		0.	0.	0.	10601.	4920.	5681.	0.6155	0.	3520.
2		0.	0.	0.	10601.	4920.	5681.	0.3838	0.	2180.
3		0.	91.	-91.	10601.	4920.	5681.	0.2378	-22.	1351.
4		0.	0.	0.	10601.	4920.	5681.	0.1473	0.	837.
5		0.	581.	-581.	10601.	4920.	5681.	0.0913	-53.	518.
6		3363.	91.	3272.	10601.	4920.	5681.	0.0565	185.	321.
7		0.	0.	0.	10601.	4920.	5681.	0.0350	0.	199.
8		6856.	0.	6856.	10601.	4920.	5681.	0.0217	149.	123.
9		0.	91.	-91.	10601.	4920.	5681.	0.0134	-1.	76.
10		0.	581.	-581.	10601.	4920.	5681.	0.0083	-5.	47.
11		0.	0.	0.	10601.	4920.	5681.	0.0052	0.	29.
12		3363.	91.	3272.	10601.	4920.	5681.	0.0032	10.	18.
13		0.	0.	0.	10601.	4920.	5681.	0.0020	0.	11.
14		0.	0.	0.	10601.	4920.	5681.	0.0012	0.	7.
15		0.	2292.	-2292.	10601.	4920.	5681.	0.0008	-2.	4.
16		6856.	0.	6856.	10601.	4920.	5681.	0.0005	3.	3.
17		0.	0.	0.	10601.	4920.	5681.	0.0003	0.	2.
18		3363.	91.	3272.	10601.	4920.	5681.	0.0002	1.	1.
19		0.	0.	0.	10601.	4920.	5681.	0.0001	0.	1.
20		-6738.	-1085.	-5653.	0.	0.	0.	0.0001	-0.	0.
	TOTAL	28339.	-5116.	23223.	201419.	93480.	107939.		9249.	9249.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100HT SAVINGS	PRESENT VALUE IN P/100HT OUTLAY	PRESENT VALUE IN P/100HT DIFFERENCE
5.000	3.771	68657.	18206.	50451.
8.000	3.378	54558.	16152.	38406.
12.000	2.952	41845.	14175.	27670.
25.000	2.034	22397.	11011.	11385.
30.000	1.799	18807.	10452.	8355.
35.000	1.607	16177.	10065.	6112.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
MECHANIZED SYSTEM INVOLVING THE AXIAL-FLOW THRESHER AND TWIN-BED BATCH DRYER COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING THE FLAIL/STICK, WOODEN WINNOWER(HUNGKOY) FOR CLEANING AND DRYING PADDY UNDER THE SUN.

A LISTING OF THE CATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN BICOL REGION,PHILIPPINES

YEAR	INVESTMENT	OUTLAY	B A S E	C A S E		A L T E R N A T I V E	C A S E			
	ALTERNATE	BASE	LABOR	REPAIRS	LOSS	LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	5320.	2292.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
2	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
3	0.	91.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
4	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
5	0.	581.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
6	3363.	91.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
7	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
8	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
9	0.	91.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
10	0.	581.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
11	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
12	3363.	91.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
13	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
14	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
15	1620.	2292.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
16	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
17	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
18	3363.	91.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
19	0.	0.	7240.	115.	3246.	2356.	451.	1600.	645.	0.
20	-3675.	-1085.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN BICOL REGION, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL 183.309 PERCENT

PERIOD		COMPARATIVE OUTLAY (P/100MT)			COMPARATIVE COST** (P/100MT)			PRESENT VALUE FACTOR	PRESENT VALUES	
NO.	IDENT.	ALTERNATIVE	BASE CASE	DIFFERENCE	BASE CASE	ALTERNATIVE	DIFFERENCE		OUTLAY	SAVINGS
0		5320.	2292.	3028.	0.	0.	0.	1.0000	3028.	0.
1		0.	0.	0.	10601.	5052.	5549.	0.3530	0.	1959.
2		0.	0.	0.	10601.	5052.	5549.	0.1246	0.	691.
3		0.	91.	-91.	10601.	5052.	5549.	0.0440	-4.	244.
4		0.	0.	0.	10601.	5052.	5549.	0.0155	0.	86.
5		0.	581.	-581.	10601.	5052.	5549.	0.0055	-3.	30.
6		3363.	91.	3272.	10601.	5052.	5549.	0.0019	6.	11.
7		0.	0.	0.	10601.	5052.	5549.	0.0007	0.	4.
8		0.	0.	0.	10601.	5052.	5549.	0.0002	0.	1.
9		0.	91.	-91.	10601.	5052.	5549.	0.0001	-0.	0.
10		0.	581.	-581.	10601.	5052.	5549.	0.0000	-0.	0.
11		0.	0.	0.	10601.	5052.	5549.	0.0000	0.	0.
12		3363.	91.	3272.	10601.	5052.	5549.	0.0000	0.	0.
13		0.	0.	0.	10601.	5052.	5549.	0.0000	0.	0.
14		0.	0.	0.	10601.	5052.	5549.	0.0000	-0.	0.
15		1620.	2292.	-672.	10601.	5052.	5549.	0.0000	0.	0.
16		0.	0.	0.	10601.	5052.	5549.	0.0000	0.	0.
17		0.	0.	0.	10601.	5052.	5549.	0.0000	0.	0.
18		3363.	91.	3272.	10601.	5052.	5549.	0.0000	0.	0.
19		0.	0.	0.	10601.	5052.	5549.	0.0000	0.	0.
20		-3675.	-1085.	-2590.	0.	0.	0.	0.0000	-0.	0.
	TOTAL	13354.	-5116.	8238.	201419.	95988.	105431.		3027.	3027.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100MT SAVINGS	OUTLAY	DIFFERENCE
5.000	10.474	67061.	6403.	60659.
8.000	9.413	53290.	5658.	47632.
12.000	8.265	40873.	4945.	35927.
25.000	5.750	21876.	3804.	18072.
30.000	5.103	18370.	3600.	14770.
35.000	4.571	15801.	3457.	12344.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
AXIAL-FLOW THRESHING COMBINED WITH SUN-DRYING COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING THE FLAIL/STICK, WOODEN WINNOWER(HUNGKOY) FOR CLEANING AND DRYING PADDY UNDER THE SUN.

A LISTING OF THE DATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN BICOL REGION,PHILIPPINES

YEAR	INVESTMENT	OUTLAY	BASE CASE			ALTERNATIVE CASE				
	ALTERNATE	BASE	LABOR	REPAIRS	LOSS	LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	8275.	2292.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
2	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
3	0.	91.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
4	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
5	699.	581.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
6	0.	91.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
7	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
8	6856.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
9	0.	91.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
10	699.	581.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
11	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
12	0.	91.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
13	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
14	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
15	699.	2292.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
16	6856.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
17	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
18	0.	91.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
19	0.	0.	7240.	115.	3246.	4961.	793.	2818.	2295.	-1625.
20	-4148.	-1085.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN BICOL REGION, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL __14.661_ PERCENT

PERIOD NO.	PERIOD IDENT.	COMPARATIVE OUTLAY (P/100MT.) ALTERNATIVE	COMPARATIVE OUTLAY (P/100MT.) BASE CASE	COMPARATIVE OUTLAY (P/100MT.) DIFFERENCE	COMPARATIVE COST** (P/100MT.) BASE CASE	COMPARATIVE COST** (P/100MT.) ALTERNATIVE	COMPARATIVE COST** (P/100MT.) DIFFERENCE	PRESENT VALUE FACTOR	PRESENT VALUES OUTLAY	PRESENT VALUES SAVINGS
0		8275.	2292.	5983.	0.	0.	0.	1.0000	5983.	0.
1		0.	0.	0.	10601.	9242.	1359.	0.8721	0.	1185.
2		0.	0.	0.	10601.	9242.	1359.	0.7606	0.	1034.
3		0.	91.	-91.	10601.	9242.	1359.	0.6633	-60.	901.
4		0.	0.	0.	10601.	9242.	1359.	0.5785	0.	786.
5		699.	581.	118.	10601.	9242.	1359.	0.5045	60.	686.
6		0.	91.	-91.	10601.	9242.	1359.	0.4400	-40.	598.
7		0.	0.	0.	10601.	9242.	1359.	0.3837	0.	521.
8		6856.	0.	6856.	10601.	9242.	1359.	0.3347	2294.	455.
9		0.	91.	-91.	10601.	9242.	1359.	0.2919	-27.	397.
10		699.	581.	118.	10601.	9242.	1359.	0.2545	30.	346.
11		0.	0.	0.	10601.	9242.	1359.	0.2220	0.	302.
12		0.	91.	-91.	10601.	9242.	1359.	0.1936	-18.	263.
13		0.	0.	0.	10601.	9242.	1359.	0.1688	0.	229.
14		0.	0.	0.	10601.	9242.	1359.	0.1473	0.	200.
15		699.	2292.	-1593.	10601.	9242.	1359.	0.1284	-205.	175.
16		6856.	0.	6856.	10601.	9242.	1359.	0.1120	768.	152.
17		0.	0.	0.	10601.	9242.	1359.	0.0977	0.	133.
18		0.	91.	-91.	10601.	9242.	1359.	0.0852	-8.	116.
19		0.	0.	0.	10601.	9242.	1359.	0.0743	0.	101.
20		-4148.	-1085.	-3063.	0.	0.	0.	0.0648	-198.	0.
	TOTAL	19936.	-5116.	14820.	201419.	175598.	25821.		8579.	8579.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/100MT. SAVINGS	PRESENT VALUE IN P/100MT. OUTLAY	PRESENT VALUE IN P/100MT. DIFFERENCE
5.000	1.402	16424.	11715.	4709.
8.000	1.251	13051.	10430.	2621.
12.000	1.089	10010.	9188.	822.
25.000	0.745	5358.	7196.	-1838.
30.000	0.657	4499.	6846.	-2347.
35.000	0.586	3870.	6607.	-2737.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE

POSTHARVEST SYSTEM USING THRESHING FRAME(HAMPASAN) AND WOODEN WINNOWER(HUNGKOY) COMBINED WITH BATCH DRYING COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING FLAIL/STICK, WOODENWINNOWER FOR CLEANING AND DRYING PADDY UNDER THE SUN

A LISTING OF THE CATA

1 1 3 5 5 3 0 2 0.0

COMPARATIVE RETURNS BETWEEN ALTERNATIVE
POSTHARVEST TECHNOLOGIES IN BICOL REGION,PHILIPPINES

YEAR	INVESTMENT ALTERNATE	OUTLAY BASE	B A S E C A S E LABOR	REPAIRS	LOSS	A L T E R N A T I V E C A S E LABOR	REPAIRS	LOSS	FUEL	PREMIUM
0	2319.	2292.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
2	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
3	0.	91.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
4	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
5	699.	581.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
6	0.	91.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
7	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
8	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
9	0.	91.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
10	699.	581.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
11	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
12	0.	91.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
13	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
14	0.	0.	7240.	115.	3246.	5678.	1160.	35800.	0.	0.
15	2319.	2292.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
16	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
17	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
18	0.	91.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
19	0.	0.	7240.	115.	3246.	5678.	116.	3580.	0.	0.
20	-1085.	-1085.	0.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

COMPARATIVE RETURNS BETWEEN ALTERNATIVE POSTHARVEST TECHNOLOGIES IN BICOL REGION, PHILIPPINES

COMPARATIVE RETURN ON TOTAL CAPITAL 7.206 PERCENT

PERIOD NO.	PERIOD IDENT.	COMPARATIVE OUTLAY (P/1000MT.) ALTERNATIVE	BASE CASE	DIFFERENCE	COMPARATIVE COST** (P/1000MT.) BASE CASE	ALTERNATIVE	DIFFERENCE	PRESENT VALUE FACTOR	PRESENT VALUES OUTLAY	SAVINGS
0		2319.	2292.	27.	0.	0.	0.	1.0000	27.	0.
1		0.	0.	0.	10601.	9374.	1227.	0.9328	0.	1145.
2		0.	0.	0.	10601.	9374.	1227.	0.8701	0.	1068.
3		0.	91.	-91.	10601.	9374.	1227.	0.8116	-74.	996.
4		0.	0.	0.	10601.	9374.	1227.	0.7570	0.	929.
5		699.	581.	118.	10601.	9374.	1227.	0.7062	83.	866.
6		0.	91.	-91.	10601.	9374.	1227.	0.6587	-60.	808.
7		0.	0.	0.	10601.	9374.	1227.	0.6144	0.	754.
8		0.	0.	0.	10601.	9374.	1227.	0.5731	0.	703.
9		0.	91.	-91.	10601.	9374.	1227.	0.5346	-49.	656.
10		699.	581.	118.	10601.	9374.	1227.	0.4987	59.	612.
11		0.	0.	0.	10601.	9374.	1227.	0.4651	0.	571.
12		0.	91.	-91.	10601.	9374.	1227.	0.4339	-39.	532.
13		0.	0.	0.	10601.	9374.	1227.	0.4047	0.	497.
14		0.	0.	0.	10601.	42638.	-32037.	0.3775	0.	-12094.
15		2319.	2292.	27.	10601.	9374.	1227.	0.3521	10.	432.
16		0.	0.	0.	10601.	9374.	1227.	0.3285	0.	403.
17		0.	0.	0.	10601.	9374.	1227.	0.3064	0.	376.
18		0.	91.	-91.	10601.	9374.	1227.	0.2858	-26.	351.
19		0.	0.	0.	10601.	9374.	1227.	0.2666	0.	327.
20		-1085.	-1085.	0.	0.	0.	0.	0.2487	0.	0.
	TOTAL	4951.	-5116.	-165.	201419.	211370.	-9951.		-69.	-69.

INTEREST PER CENT	COMPARATIVE RATIO	PRESENT VALUE IN P/1000MT. SAVINGS	OUTLAY	DIFFERENCE
5.000	22.213	-1972.	-89.	-1883.
8.000	-7.216	459.	-64.	522.
12.000	-53.127	2231.	-42.	2273.
25.000	*******	3374.	-11.	3386.
30.000	*******	3217.	-6.	3223.
35.000	*******	2996.	-2.	2997.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:

POSTHARVEST SYSTEM USING THRESHING FRAME(HAMPASAN) AND WOODEN WINNOWER(HUNGKOY) AND SUN-DRYING COMPARED WITH THE BASE CASE WHICH IS THE TRADITIONAL SYSTEM OF THRESHING USING FLAIL/STICK,WOODEN WINNOWER(HUNGKOY) FOR CLEANING AND PADDY SUN-DRYING.

Appendix Table F-1. Net present values of traditonal threshing and cleaning using threshing frame and winnowing basket combined with mechanical drying, Central Luzon, Philippines, 1975-77.

Alternative Wage Rates and Price Premiums	Discount Rate 5	8	12	25	30	35
Cash Wage and no premium			not feasible			
" " " 0.5% "			not feasible			
" " " 1.0% "	-2348	-2744	-3042	-3438	-3526	-3604
" " " 1.5% "	1579	377	-648	-2157	-2450	-2678
" " " 2.0% "	17290	12861	8927	2968	1853	1024
Wage in-kind and no premium			not feasible			
" " "			not feasible			
" " " 1.0% "	-2342	-2740	-3038	-3436	-3525	-3602
" " " 1.5% "	7477	5063	2946	-233	-835	-1289
" " " 2.0% "	17296	12866	8931	2970	1855	1025

Appendix Table F-2. Comparative ratios of traditional threshing and cleaning using the threshing frame and winnowing basket combined with mechanical drying, Central Luzon, Philippines, 1975-77.

Alternative Wage Rates and Price Premiums	Discount Rate					
	5	8	12	25	30	35
Cash wage and no premium			not feasible			
" " " 0.5% "			not feasible			
" " " 1.0% "	0.736	0.654	0.567	0.383	0.337	0.299
" " " 1.5% "	1.841	1.637	1.419	0.958	0.843	0.749
" " " 2.0% "	2.946	2.620	2.270	1.533	1.349	1.199
Wage in-kind and no premium			not feasible			
" " " 0.5% "			not feasible			
" " " 1.0% "	0.736	0.655	0.568	0.383	0.337	0.300
" " " 1.5% "	1.841	1.638	1.419	0.958	0.843	0.750
" " " 2.0% "	2.946	2.620	2.271	1.533	1.349	1.199

Appendix Table F-3. Net present values (₱/100 MT) of traditional threshing and cleaning using flail/stick and wooden winnower combined with mechanical drying at alternative added wage rates, price premiums and rates of interest, Bicol Region, Philippines, 1975-77.

Alternative Wage Rates and Price Premiums	Discount Rate					
	5	8	12	25	30	35
Cash wage and no premium			not feasible			
" " " 0.5% "			not feasible			
" " " 1.0% "	-10208	-9226	-8258	-6687	-6415	-6232
" " " 1.5% "	-389	-1423	-2273	-3483	-3725	-3919
" " " 2.0% "	9430	6380	3712	-280	-1035	-1605
Wage in-kind and no premium			not feasible			
" " " 0.5% "			not feasible			
" " " 1.0% "	-10151	-9180	-8222	-6668	-6399	-6219
" " " 1.5% "	-331	-1377	-2238	-3465	-3709	-3905
" " " 2.0% "	9488	6426	3747	-261	-1019	-1591

Appendix Table F-4. Net present values and comparative ratios in traditional threshing and cleaning system (threshing frame and wooden winnower) in Bicol Region, Philippines, 1975-77.

Discount rate	Bicol Region			
	Net Present Value		Comparative Ratio	
	Cash Wage	Wage in-kind	Cash Wage	Wage in-kind
	(₱/100 MT)			
5	-1883	-1104	22.213	13.437
8	522	1141	-7.216	-16.960
12	2273	2748	-53.127	-64.432
25	3386	3640	not feasible	not feasible
30	3223	3436	" "	" "
35	2997	3181	" "	" "

APPENDIX G

INPUT-OUTPUT DATA USED IN THE COMPARATIVE RATE OF RETURN ANALYSIS BY REGION

Appendix G. Input-output data used in the comparative rate of return (CRR) analysis by region, Philippines, 1975-77.

Capital Investment	Purchase Price (₱)	Estimated Life (Years)	Hours Operated per day	Capacity per hour (tons per hour)		Total Operating Hours per year (hours/year)		Annual Capacity (tons)		Capital Investment per Annual Capacity	
				Central Luzon	Bicol	Central Luzon	Bicol	Central Luzon	Bicol	Central Luzon	Bicol
Axial-Flow Thresher		6	8	0.594	0.715	768	626	456	446	36.18	37.00
Commercial price	16,500										
Project price	9,750										
Batch Dryer		8	10	0.202	0.184	900	720	182	132	21.35	21.86
Commercial price	10,000										
Project price	8,200										
Threshing Frame (hampasan)	20	5	6	0.04	0.04	504	432	20	17	1.00	1.18
Flail/Stick	10	2	6	0.026	0.026	504	432	13	11	0.77	0.91
Winnowing basket/sieve	5	2	6	0.098	0.098	504	432	49	42	0.10	0.32
Wooden Winnower	250	5	6	0.10	0.10	504	432	50	43	5.00	5.81
Sun drying	875	15	7	0.184	0.107	588	504	108	54	8.10	16.20

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