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Bulk Handling of Paddy and Rice in Malaysia:
an Economic Analysis

Editors: **G.J. Ryland and K.M. Menz**

Australian Centre for International Agricultural Research
Canberra 1989

Foreword

ACIAR has supported a number of projects on the postharvest handling of grains in Southeast Asia. The economics-orientated project on which this report is based was formulated in recognition of the idea that new technology will only be developed and adopted where appropriate economic incentives exist.

The results showed that, in fact, such incentives are lacking in the postharvest rice sector of Malaysia. Changing policies which affect these will be a prerequisite to improved technology adoption in the postharvest sector in Malaysia, particularly with respect to grain drying. Suggestions regarding the appropriate level and type of incentives are included.

A full bulk-handling system was shown to be less desirable economically than a semi-bulk system under current conditions. Paddy and final product pricing policies were found to have a critical impact on the economic feasibility of the introduction of bulk-handling equipment. The collaboration between the various institutions involved in the project was excellent. This collaboration included not only socioeconomic, but also technical aspects.

Since the project concluded, there have been substantive discussions in Malaysia on the results. The policy recommendations stemming from the project are receiving consideration by the Malaysian authorities, and are in the process of being implemented.

J.R. McWilliam
Director
ACIAR

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Acknowledgments

THE project team acknowledges the financial and professional support from ACIAR, the Rice and Paddy Marketing Authority of Malaysia (LPN), the Malaysian Agricultural Research and Development Institute (MARDI) and Universiti Pertanian Malaysia (UPM) throughout the period of this investigation. In particular, individual contributions by Dr B.R. Champ, Coordinator, ACIAR Postharvest Research Program and Dr J.V. Remenyi, former Coordinator, Socioeconomics Research Program ACIAR, significantly enhanced the prospects for success of the project. LPN officers both in Kuala Lumpur and at LPN sites throughout West Malaysia have assisted the project team through the provision of facilities, communication and resource support. To these people we extend our thanks.

The support for the project by both current and former administrators of LPN has been particularly valuable. The project was initially implemented by Dr Shamsuddin and was carried forward by his successor Mr Sharruddin. During the latter stages of the project, Dr Kuddus, the current Director of LPN, provided additional resource support to the project. Dr Ishmail, Director of MARDI, also provided resource support to the project of which the contributions by the MARDI Computing Centre deserve special mention.

At various stages during the period of the project, the team requested additional resource support. Mr Faisal, Deputy Director of the North-West Selangor Irrigation Project (NWSIP), provided valuable assistance through his work on estimating supplies of paddy for both the dry and wet period harvest at over 200 locations in the study region. ACIAR also provided additional financial support to the project for funding the first major workshop of the project in Adelaide on 14–15 January 1986. Dr Othman, MARDI, coordinated a range of experiments on recovery rate and moisture content loss at various storage periods which supported our study on grading systems. Mr C. MacCormac (Project Officer, IDRC) gave valuable support to the project both professionally and through direct resource support in terms of Postgraduate Awards to two workers engaged on the project at UPM.

Finally, as Joint Project Leaders, we must acknowledge the enthusiasm and rigour with which all team members approached their tasks. We hope that this collaboration which has developed among all team members can be continued.

Mohd. Ghazali Mohayidin
Chew Tek Ann
George Ryland

October 1988

Introduction

Background

Malaysia is about 60% self-sufficient in the production of rice. Malaysian authorities involved in handling, storage and milling of paddy, and storage and distribution of rice, believe that introduction of innovations in handling paddy such as the adoption of modern bulk handling methods and more efficient and effective grain-drying equipment, will reduce losses significantly and improve industry performance. The Malaysian authorities also recognise the need to improve the system of incentives through changes in the paddy grading system. Consequently, the focus of this study is to provide a conceptual framework in which both technological and policy choices can be evaluated. This involves a systems analysis of grain handling in Malaysia involving all participants in the grain handling and storage subsectors, from postharvest treatment of paddy in the fields, transportation of wet paddy, paddy procurement, drying, storage and processing through the storage and distribution of milled rice to consumption regions.

Previous Studies

Postharvest handling and transportation systems of grain in North America and Australia have received considerable attention from economists over the last two decades. However, there have been relatively few spatial studies applied to the raw rice (paddy) handling and transportation system, either in North America or in the developing countries. Studies conducted in the humid tropics include those of Hugo (1981), who developed an allocation location model of publicly owned warehouses for milled rice in Sri Lanka, and Soo Lip Tan (1971) who considered the least-cost location pattern of drying facilities for paddy in the MUDA area of northwest Malaysia.

The main concern of these earlier studies was the development issue of whether investment in a few large centralised storages was of greater economic benefit than investment in a larger number of small storages. The studies examined whether cost savings from economies of scale in larger storages were sufficient to offset the increase in assembly costs of paddy at central storages relative to a more dispersed satellite pattern. Storage and transport planners in many developing countries have historically adopted a 'think big' strategy by centralising storages in larger units located at a few central places such as ports or consuming centres. Several reasons have been advanced for this storage location pattern. Firstly, there are potential size economies to be exploited with the construction of larger storages which suggests that reduction in cost through increasing size more than offsets the extra costs associated with assembling the raw material. A second and rather attractive attribute is that assembly at fewer larger places makes subsequent allocation decisions to demand centres easier.

Storage Locational Patterns

While empirical studies have generally supported the decentralisation of storage and handling facilities to nearer the production locations, purchasing policy by government has probably been the main deciding factor in the tendency toward concentration of facilities. A study of grain drying locations in Malaysia by Soo Lip Tan (1971) supported a decentralisation strategy. A recent study by Monterosso et al. (1985) of rice handling/storage in Brazil provided overwhelming empirical evidence that location of grain drying and storage at or near farms avoids spoilage and reduces dead weight by 5–10%. However, no account has been taken of the purchasing policies of raw material (paddy) which may serve to offset any transport cost savings through decentralisation. The current pricing structure of paddy in Malaysia in which quality differentials do not reflect the full resource cost of drying wet paddy has hindered the development of satellite drying and storage centres.

Quality Adjustment and Incentive Payments

The value of paddy is influenced by quality considerations. The methodology used in this study includes quality considerations in seeking to maximise net revenue to the rice processing industry. It also seeks to determine the optimal allocation (in terms of size, number and location) of all handling and processing facilities for paddy and rice simultaneously, as well as analysing the impacts of alternative transportation and handling technologies (Ryland and Guise 1975). The development planning issue of centralised versus decentralised capital investment in facilities can thus be addressed in a comprehensive manner.

In the current study, a production-location allocation model is developed in which market price and transport costs are assumed constant. Costs of storage processing and drying are throughput-related or vary with size of the facility. In this economic environment, the underlying objective is to maximise industry net revenue made up of gross revenue less total of transport and grain handling costs from raw material supply sources through storage, drying and processing facilities for distribution of final product to consumers. Imposed on this system are constraints to ensure that raw material supplies are consistent with availabilities, that bottlenecks in the system are recognised and that demands at consuming centres are satisfied.

Model Applications

The model developed for this study is specifically designed to address the issue of the impact of improved grain handling technology and changes in the paddy grading and pricing system on the current method of handling and grading. The model is also sufficiently flexible and versatile to analyse a wide range of interesting issues including storage requirements of grains, alternative drying technologies, pricing policy and the employment and social impact of modernising grain handling systems. Some of these issues are discussed briefly below.

Raw Material and Final Product Storage

Development planners and agencies are particularly interested in the issue of the appropriate balance between raw material and final product storage requirements. The amount of final product storage of a commodity depends not only on attempts to meet normal demand requirements, but also on strategic reasons such as food security and domestic price stabilisation policy. Speculative storage decisions also play a role. This would seem to be an important issue particularly in periods of potential surpluses of grains where there is considerable need for additional storages. With rice, for example, storage of dried paddy has much lower postharvest losses from insect infestation than storage of milled rice. Yet there is considerable excess capacity in the processing sector in Malaysia where the aim seems to have been to mill paddy as fast as possible. If governments are to maintain large quantities of stored grain as part of a country's insurance against fluctuations in local production, then planners need to identify the product type, location, as well as temporal dimensions of the storages. The TDRI study by Mitchell and Gray (1985) of the central storage system in Indonesia administered by BULOG did not consider the former issue. As stocks become older it is clear that BULOG in Indonesia will be required to pay increased attention to the problem of preserving grain quality.

Government Intervention

In Malaysia, the government has intervened at all levels to support the rice industry. Intervention has occurred mainly through providing input subsidies (irrigation water, fertiliser and seeds) as well as directly subsidising paddy prices, through administered prices for milled rice. There has also been control over imports. The intended consequences of these interventions is the stimulation of local food production to boost incomes of producers (so as to reduce the perceived income inequalities between urban and rural households) and to save foreign exchange. The impact of government intervention results in a massive transfer from consumers to producers causing a significant reduction in net social welfare than would be the case in the absence of price support policies. However, intervention by government has also resulted in many unintended consequences. Resource misallocation within the producing sector through distortion in the procurement system has imposed increased costs which are borne by all other participants in the rice processing, handling and distribution sectors. There is no incentive to produce good quality rice in this system, and this obviously hinders the adoption of mechanical-grain drying technology.

Capacity Utilisation

The grain handling and storage system in the humid tropics must be sufficiently versatile and flexible to meet these changing systems. For example, another reason (in addition to price distortions discussed earlier) that mechanical grain-drying equipment has not been widely adopted throughout Asia is because of the very low levels of capacity utilisation. One reason for the low utilisation is that the equipment is not multifunctional. Grain drying can be made more cost effective if it is multipurpose (includes maize, paddy, groundnuts, fish and meat) and multifunctional (integrated with a storage system so that different drying strategies can be applied on the different raw materials). Diversification in the farming system will increase the demand for multipurpose, multifunctional mechanical drying equipment.

Social Impacts

Studies associated with modernising marketing systems should not ignore the employment and social impact of changes in rice marketing. To do so, particularly in economies with a labour surplus, would tend to increase the apparently optimal rate of adoption of newer, more efficient, technology. In this study, though capital/labour ratios are not built explicitly into the model to date, externalities are considered, by assigning shadow prices whenever private and social costs diverge, in order to determine the socially optimal solution. In particular, the introduction of bulk handling of paddy and rice (Ahmad and Dhiauddin 1984) may have some undesirable social consequences in terms of increased unemployment, increased wear and tear on local roads as well as on the gunny sack barter systems. The potential gains from the introduction of bulk handling equipment will have to be sufficient to offset these social costs. In addition, the private investment costs in the necessary infrastructure for bulk handling of paddy and rice will have to be met if any contemplated change in the present system is to be economic in social cost/benefit terms.

This study encapsulates the model building conceptual framework used for analysing grain handling and transportation in more developed economies. The model is then applied to a situation which incorporates all the diverse components of paddy assembly, procurement, drying, storage and processing and storage and distribution of milled rice. The model-building approach imposes a discipline on the researchers involved to thoroughly understand the system which is being modeled as well as assembling a sufficiently comprehensive and informative data base so that the orders of magnitude of the different modules involved can be satisfactorily estimated at least in a relative sense. The modeling approach was necessary in order to capture the linkages between all postharvest activities so that both direct and indirect effects of changes in modern grain handling and storage technology can be analysed.

Project Perspective

Aims and Objectives

The overall objective of the project was the development of a model of the Malaysian rice economy in order to integrate all diverse components of the paddy and rice handling industry. The model was evaluated empirically using observed data from the Tanjung Karang area in Northwest Selangor. An assessment was also made of the extent to which the model is generally applicable to other rice-producing regions in Malaysia. The model was used to analyse alternative paddy transport and handling activities as well as paddy grading systems so as to determine the most socially-efficient locational pattern, number, and size of paddy handling and rice distribution facilities.

The specific objectives are:

1. To develop an appropriate methodology for analysing from the viewpoint of the Malaysian rice economy, the optimal postharvest storage, handling, drying and grading requirements and shipment patterns of paddy and rice;

2. To calibrate and empirically evaluate the model using observed data collected in a given season for a specified region in Malaysia;

3. To analyse, using the model, the effect of nominated changes in appropriate decision variables such as storage and transportation costs, and capacities of the distribution system on total paddy handling costs.

Scope of the Study

Rice production in Peninsular Malaysia has undergone rapid expansion stimulated by a range of government interventions such as provision of irrigation facilities and the introduction of high-yielding varieties of paddy. In 1965, 363 000 ha were planted to rice in the dry season and 36 000 ha in the wet season, producing a little over 1 million tonnes of paddy. By the mid 1970s, area planted had risen to around 570 000 ha with the prime increase occurring as a result of the marked rise in wet-season crop (the percentage of double cropping had risen from 10% in 1965 to around 60% in the mid 1970s). This trend has continued with Peninsula Malaysia producing about 1.66 million tonnes of paddy annually, 44% of this being off season (Ministry of Agriculture, Malaysia, 1965–84). Imports, however, have remained virtually unchanged in absolute terms over this period, apart from seasonal influences. In 1965, imports were about 50% of production, while in recent times they have fallen to around 35% of production.

Technological Change

Malaysian farmers have been quick to adopt new production technology (high-yielding varieties, double-cropping techniques and mechanical harvesting) which not only shorten the harvest period but also place pressures on paddy postharvest handling facilities. This has resulted in congestion at handling facilities which has contributed to bottlenecks and lengthy delays in the paddy delivery system. It has been estimated that up to 18% of annual paddy production in Malaysia is lost due to postharvest deterioration (Fredericks and Wells 1983). If this level of postharvest losses could be reduced, Malaysia would become closer to self-sufficiency in rice.

Institutional Framework

Rice marketing in Malaysia is government-controlled through subsidies and guaranteed minimum prices on purchases of paddy from farmers and regulated retail prices of rice (Chew and Ghaffar 1986). The Rice and Paddy Marketing Authority of Malaysia (LPN) is responsible for regulating domestic prices of rice and is the sole importer of rice. This Authority operates 33 large integrated rice complexes and is faced with the complex recurring problem of sizing and locating mills.

Paddy Grading System

The choice of location, number and size (LNS) of paddy handling facilities is a complex problem which is faced by all agencies involved in the investment planning of paddy and rice distribution networks. The problem is exacerbated by a grading system for paddy which discriminates against both buyers and sellers of paddy at different points in the system because quality differentials for paddy are not accurately reflected in prices. An improved grading system for paddy would provide the necessary incentives for farmers to deliver paddy in a condition which reflects the savings in resource costs involved in improved milling efficiency. This system would also require the processor/buyer of paddy to segregate paddy stocks prior to storage in which case the additional costs of doing this would need to be offset by the additional returns from milled rice of various qualities.

Modeling Framework

A mathematical programming model which incorporates all the above factors can be used as a decision-making tool in helping determine the most economically efficient paddy and rice handling system. Such a model would be an extension of earlier work by Ryland and Guise (1975) who developed a space/time/quality model which was used for handling temporal quality deterioration problems and spatial patterns of production in relation to the organisation of the sugar industry in Australia. The model can be used to examine a number of contemporary issues in paddy and rice handling.

Contemporary Issues

Contemporary issues in grain handling in Malaysia include:

- the impact on the current system of an improved bulk handling facility;
- storage systems for paddy and rice;
- choice among types of drying equipment;
- centralised compared with decentralised paddy storage and drying equipment; and
- increasing utilisation rates of rice mills compared with the costs of additional storage of paddy which would otherwise be needed; and the impact of alternative grading systems on optimal industry performance.

Each of these issues can be examined using the model by using conventional postoptimality sensitivity analysis or by specifying additional constraints and/or modifying cost/revenue parameters.

Malaysian Postharvest Paddy/Rice System

The location, number and size of paddy handling and processing facilities and the spatial and temporal flows of paddy influence, and are influenced by, the behaviour of a number of participants in the physical handling and processing system for paddy. A flow chart showing the participants of the handling and storage system of paddy and milled rice in Peninsula Malaysia is given in Fig. 1.

The principal components of the processing and transportation system are: paddy production, contract carting, drying of paddy, storage of paddy, milling of paddy, transportation of milled rice to markets, domestic grain utilisation.

The paddy handling, transportation and processing system encompasses a large number of participants. Each participant makes decisions which influence and are influenced by the activities of others in the system. Ideally, for an efficient system to evolve, each participant should incur the full costs and benefits of his actions. When this condition does not hold, inefficiencies may occur. For example, the Malaysian Paddy and Rice Marketing Authority (LPN) could attempt to reduce costs by reducing the number of handling facilities it operates. However, the resulting increase in assembly and queuing costs incurred by growers may more than offset any savings in handling costs, thereby resulting in a net social loss to the community. Consequently, the actions of *all* participants need to be taken into account in order to arrive at the most socially efficient location pattern of paddy handling facilities. This will be determined along with the optimal spatial and temporal flows of paddy given the locations, quantities and grade distributions of paddy supplies and demands.

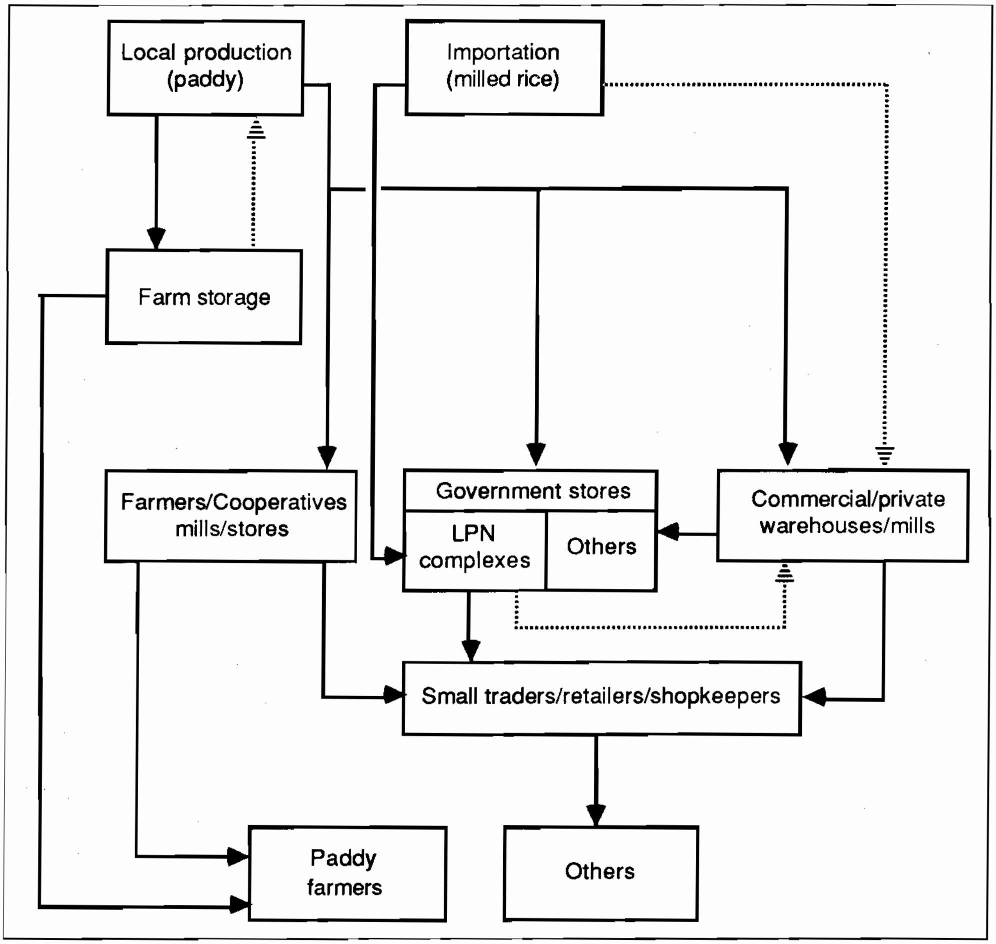

Fig. 1. Flow chart of the handling and storage of rice in Peninsular Malaysia (from Fredericks and Wells 1983).

Model Specification

Economic Environment

The postharvest system operating in Malaysia can be modeled by assuming farmers supply either wet or stored (dried) paddy to procurement centres, government rice complexes or private mills. Supply points are assumed to be representative of around 50 farmers who coordinate their actions in transporting paddy to these markets so as to minimise their perceived costs. If wet paddy is transported from farms, it is dried prior to storage and milling. Dry paddy passes through a production process to become milled rice of different grades, which is the end product. The conversion factors between wet and dried paddy, and dried paddy and rice are essentially quality adjustment factors which are exogenously determined, and can vary at different plant locations (space) and through time. Plant capacities and locations are known and fixed in the short term, while in the intermediate and long term, the capacities at each location can be determined as part of the model's solution.

A predetermined quantity of rice of different grades is assumed to be demanded at each final rice market in each time period. Similarly, dry paddy demand by private millers is exogenously determined (the model assumes perfectly inelastic demand). At each plant the costs of production are known and defined by total cost functions. All paddy supply points, production locations and final markets are separated by transportation costs per physical unit for each type of product, and these costs are known. The planning horizon is limited to four periods, two harvest and two postharvest periods, so as to simulate a single annual harvesting and milling season.

For the empirical model it is assumed that, when total paddy supplies are converted into milled rice, the resulting total supply of final product is at least equal to demand requirements. At each processing centre and demand region, each type of rice produced is of similar quality, implying that those who demand the products are indifferent as to their source of supply. The handling and processing industry is assumed to compete for supplies of paddy on the basis of locational advantage. Market demand prices are known and fixed, as are the prices paid to paddy producers. The market prices and producer prices can be different in the four time periods.

Model Specification

The objective of the paddy/rice industry in Malaysia can be thought of in terms of the maximisation of the annual net revenue of the processing industry for paddy less all postharvest costs including paddy purchase, drying, transporting, milling and storage costs for paddy and rice. Where appropriate, postharvest costs are determined through estimation of cost functions. Typically, total cost functions are dependent upon resource throughput and plant capacity. The objective function for a short run environment with investment fixed is subject to various constraints, reflecting amongst many other things, restrictions on grain flows due to storage and drying capacities at procurement centres and government rice complexes. For example, constraints imposed on paddy and rice flows ensure that flows of paddy from regions do not exceed supply. Their respective shadow prices are the imputed marginal average values of paddy/rice at various locations over time. The imputed marginal value or rent of an additional unit of capacity (either storage, milling, drying or handling) is also obtained. A detailed specification of the objective function, constraint equations, variable definitions and subscripts describing the model, is contained in Ryland and Hansen (1986).

Longer Term Considerations

The above paddy/rice handling and processing model defines a short-term economic environment of one harvesting year in which there are two crops, with grain handling facilities representing sunk capital costs. Such sunk costs mean site and equipment disposal is not an option in the short term. On the other hand, all operating costs of grain-drying equipment, storage for paddy and rice and rice mills are avoidable and are variable within the model. In the short run the model is used to determine the optimal flow pattern of paddy and rice between production and market locations while the location, number and size of handling and processing facilities remain fixed. In the long run economic environment, the location, number and size of all grain handling and milling facilities are variable. All costs are changeable, meaning all capital costs and operating costs of all production/handling facilities and assembly costs (transportation, transfer and queuing costs) are minimised simultaneously. From a finite number of feasible sites, optimal location, number and size of production/handling facilities are determined, together with the optimal flows of paddy and rice between points of regional supply, processing locations and final markets. However, while this long run solution will indicate the savings which would accrue to the industry if it were to be developed from scratch again it is only of academic interest from the industry planning viewpoint. Baumel et al. (1973), Sweeney and Totham (1976), Read and Watson (1982) and others argue that existing configurations cannot be immediately redesigned to implement the long run optimal solution and that existing facilities in fact affect the optimal path of industry adjustment due to the nature of their sunk costs (Lifferth 1974).

Intermediate Run

Lytle and Hill (1973), Kerin (1983) and Monterosso et al. (1985) have analysed the intermediate-run environment assuming capital costs associated with construction costs of existing facilities are sunk while other capital costs such as holding costs (rates/taxes) associated with existing facilities are regarded as avoidable by site disposal or abandonment. The intermediate run case is considered the most relevant for planning purposes in this study. In this environment, imputed and annualised capital costs of constructing existing production/handling facilities are unavoidable while holding costs are avoidable. On the other hand, capital costs of new facilities are avoidable, and as such, the annualised capital costs are included in the model. All operating costs and transportation and other assembly costs are also included. When these costs are included in the model, it can be used to evaluate two alternative planning environments in which existing facilities can either be rationalised or additional facilities built. In the latter case, the model also determines the size, number and location of additional facilities. In these planning situations the present capital structure of the paddy/rice processing industry is regarded as fixed.

Empirical Application in this Study

Our empirical results and solutions are based *on the short-run version of the model* only for this study. However researchers employed on the study are examining location, size and number of plants (i.e. the longer term solution) as part of their ongoing activities. The emphasis in this study is to demonstrate the potential benefits of bulk handling using alternative systems judged to be technically feasible.

The model which has been developed draws together the decentralised decision-making behaviour of all participants in the postharvest system. A detailed discussion of the economic conditions underlying each equation which reflects behaviour of each participant is contained in Ryland and Hansen (1986). This set of economic conditions derived from the Kuhn-Tucker necessary conditions for an optimum solution of any mathematical programming problem. An optimum solution was obtained in about 12 000 iterations and the optimal base was saved after this point.

Data Requirements

The Region and Application

The district of Tanjung Karang of northwest Selangor was selected for the purpose of this study. The study area is divided into eight production areas consisting of Sawah Sempadan, Sungai Burong, Sekincan, Sungai Leman, Pasir Panjang, Sungai Nipah, Pancang Bedana and Bagan Terap. Paddy cultivation in these areas is mostly done manually but in some areas mechanical equipment is used. Most of the farmers in this region cultivate paddy twice a year except in Sekincan where some farmers plant paddy five times in 2 years. Harvesting is done mostly by mechanical equipment. Farmers can sell their paddy direct to four LPN complexes or to procurement centres which are appointed by the LPN. There are 41 procurement centres, 35 farmer cooperatives and 6 farmer associations. A detailed physical description of this region is contained in a paper by Omar bin Yob (1986).

The region differs from other major rice-producing regions in two respects. First, there is a system of satellite purchasing stations already in operation and hence data can be obtained for analysing a situation where all satellite purchasing centres are removed relative to the status quo. Second, LPN is the sole miller in this region and hence adoption of new technology is a decision which LPN itself can make for many of its functions.

Marketing of Paddy

The short-term model specified in this study has been applied to the 1984-85 harvest period situation in the Tanjung Karang region in northwest Selangor, Malaysia. Double cropping techniques and mechanical harvesting are practiced in this region where total area under paddy production is about 19 000 ha, producing around 60 000 t of wet paddy each season. About 50% of this production is marketed through the Rice and Paddy Marketing Authority which is the sole buyer of paddy in the region. Private mills do not operate. Farmer cooperatives and associations are appointed as procurement agents on behalf of the government rice complexes. Under these marketing arrangements farmers are able to sell directly to these complexes or to procurement centres (buying agents). At the place of paddy sales, grading is carried out on the basis of grain moisture content, impurities, empty and immature grain content. Farmers are paid on the basis of net dry weight of paddy sold (Omar 1986). However the level of discounts does not reflect the full costs of drying high-moisture grains. Drying, milling and paddy/rice storage are provided at government rice complexes only, while additional rice storage ('godowns') is available at the wholesale markets in consuming centres.

This study incorporates eight production areas where harvesting is staggered due to water supply policies of the northwest Selangor Irrigation Development Project (NWSIP). Each area is split into production blocks based on canal location. There is a total 147 blocks over the eight areas. Yields in Tanjung Karang average 3.2 t/ha/season. Actual area harvested and production data were provided by the Irrigation Authority (NWSIP) for the production period 1984-85.

Delivery Networks

There are 35 farmer cooperatives and 6 farmer associations acting as procurement centres, and 4 government rice complexes servicing the production area. Distances from each production block to each receival facility are taken from the mid-point of each block. The estimation of supply points, supplies of paddy at each supply point and the transportation network from each supply point to mills and procurement centres is documented in two papers (Omar bin Yob 1986). Only physically feasible transportation routes were chosen for examination, giving about 2000 different routes per season over all quality grades.

Cost Data

At the commencement of the project it was decided that there were three areas in which cost and physical data would have to be collected. These data related to assembly, processing and pricing systems. Each of these areas of data collection is described briefly below.

Assembly. A preliminary survey to obtain assembly cost data and physical characteristics of the paddy transport system was conducted in Tanjung Karang during August-October 1985. The survey procedure was based upon Kerin's (1985) study of assembly operations for grain in South Australia. Results of the survey are documented in Ghazali and Muzafar (1986). The main results of this investigation were as follows:

- Contract operators accounted for 93% of all deliveries of paddy at procurement centres and LPN complexes. However they accounted for less than 20% of vehicles delivering grain to these complexes;
- Queuing cost was positively related to the quantity of grain received each season and negatively related to the total number of workers at each receival site;
- Total road transport charges were positively related to trip distance, quantity of grain carried and expected queuing cost; and
- Queuing accounts on average for about 70% of total assembly costs.

A similar survey (unpublished) was also conducted in the MUDA region of Malaysia during February–March 1986. The main differences in the two survey results was that queuing cost was significantly less at private mills relative to LPN complexes and that farmers rather than contract carters were mainly responsible for the delivering of the wet paddy to mills. Congestion costs were significantly higher in the MUDA region relative to Tanjung Karang.

Processing. Ghaffar and Hassan (1985) have conducted analyses of drying and milling costs. Their analyses suggest that drying and milling costs are more sensitive to throughput than capacity. Their investigations are contained in three papers (Ghaffar and Hassan 1985, 1986,1987). The approach adopted for this study was based on estimating a statistical cost function in which costs were hypothesised to be functionally related to output and capacity. The data used for this analysis were obtained from a cross-section survey of 31 government-owned rice milling and drying complexes in Malaysia. These mills exhibit a remarkable degree of diversity in both managerial systems and in milling and drying technology. Costs were classified according to whether they vary with throughput (labour/materials) and non-throughput related (depreciation and administration).

Drying costs. While there exists a diversity of drying methods (continuous flow, flat bed and moisture extraction units) and a range of drying strategies, most wet paddy handled passes through the continuous-flow type dryer at least once for both precleaning and drying purposes. Thus drying capacity was based on one pass of the continuous-flow dryer for an operating period of 16 hours/day over a season of 200 days.

The major conclusions of the drying/milling cost study are:

- energy and depreciation of equipment account for about 50% of milling cost and 65% of drying cost;
- administrative overheads account for approximately 30% of the total operating cost (drying and milling) for an integrated complex; and
- there is evidence of substantial unexploited scale economies in drying at LPN complexes.

Quality Adjustment Parameters

In the model there are two parameters which can be varied to provide useful insights into the impacts of alternative distributions of paddy quality on the optimal spatial organisation of drying and storage facilities. One quality parameter is used for converting wet paddy of 24% moisture content to its dried equivalent of 14%, and the other is the marketable rice recovery rate from dried paddy. Chew and Ghaffar (1985) showed that significant quality variations cannot be detected in the paddy harvested from different localities in the area under study. Their examination of weight deductions on paddy received at two government collecting centres revealed that the deductions are more or less similar, implying similar qualities of paddy delivered. This would be expected given the controlled irrigation production practices of paddy producers in the region. In that study it was also reported that rice produced from the different paddy processing plants comprised similar grades. The approach adopted in this study is to assume a standard wet and dry paddy moisture content throughout the entire study region. Postoptimal analysis using the quality function can be conducted by varying the parameters over feasible ranges. For example as quality varies, a functional relationship between paddy price and moisture content provides movements in head rice percentage (recovery rate) which can be used to determine the sensitivity of changes in quality on supply prices of paddy which are generated as shadow prices (dual prices) by the model. These prices impute a value on paddy of different qualities which reflect its value to the processing industry and are useful in developing a grade/price related system.

Paddy Quality and Incentive Payment Schemes

The current system for purchasing paddy in Malaysia encourages the delivery of wet paddy to all procurement centres and government rice complexes. This is primarily due to the government-controlled pricing system used for discounting paddy of inferior quality. The current paddy pricing structures are not sufficient to recover all resource costs involved in drying and cleaning paddy of inferior quality. The model can be used to examine the impact of changes in paddy pricing structures on industry net revenue and locational patterns of drying facilities. In addition the model can be used to analyse the extent to which paddy pricing must change in order to provide sufficient economic incentive for the introduction of grain handling technology such as the handling of all products in bulk. In many situations in Asia improved postharvest technology will take place when appropriate economic signals are provided.

The overwhelming conclusion that emerges from this aspect of the project is that the paddy pricing system plays the pivotal role in the overall performance of the paddy/rice industry in Malaysia. Chew and Loo (1985) have written a seminal article on the economic thresholds levels of drying in which the economic optimum level is where marginal revenue of extra drying is equated with marginal costs incurred from drying. Ryland (1986) developed this theme further to include social as well as private costs and benefits. The paddy procurement systems adopted by government agencies in ASEAN, all of which use a moisture deduction system, were reviewed by Chew and Arshad (1986). It was found that Thailand has the most free and competitive paddy/rice industry followed by Philippines and Indonesia. Government intervention is greatest in Malaysia. The same pattern also applied with respect to economically efficient moisture deduction rates.

In a free and competitive paddy/rice industry the prices of wet and dry paddy would be sufficiently different to ensure that drying of paddy is sufficiently remunerative to whichever party performs this vital task. Government intervention that inhibits this price behaviour of wet paddy versus dry paddy, as in Malaysia, can only result in a cost to the country, in terms of grain losses through biological deterioration and an economically inefficient paddy/rice flow.

Summary of Costs Used in the Model

The short-run situation portrayed in this model has been applied to the 1984-85 harvested period in Tanjung Karang. Data used are from the wet season harvested period. The assembly cost functions used were estimated by Ghazali and Muzaffar (1985) using data collected from farmers and contractors operating during the August-October 1986 wet season harvest period. The average queuing cost is reported to be $M14/t of paddy. The costs used for drying, milling, handling and storage are from the preliminary analysis by Ghaffar and Hassan (1985) on the data collected directly from LPN complexes. The cost of drying is $M71.28, milling is $M67.03, handling is $M6.06 and storage is $M1/t of paddy rice/month. The buying price of wet paddy is on average $M573.30/t which is being used in this model. This price is estimated after considering the government subsidy, impurities and moisture deduction. The wet paddy received is dried to 14% moisture content for storage giving a conversion factor of 1.13 t of wet paddy being equivalent to 1 t of dry paddy. When milled, dried paddy gives 660 kg of marketable rice, which is equivalent to 66% recovery rate.

Discussion of Results

Basic Results

The basic solution to the model is given in Table 1. The total income derived from the sale of rice is approximately $M35.6 million while total industry cost is $M43.9 million giving a net industry loss of approximately $M8.3 million annually. The model gives an optimal network which confirms farmers' rationality with respect to paddy deliveries. The solution revealed that approximately 73% of total paddy deliveries of around 64 000 t were delivered to procurement centres which implies that farmers will readily accept a system whereby they incur higher private transport costs so long as these private costs are offset by lower congestion costs at delivery centres. Of all other marketing costs (excluding paddy purchase and subsidy), the costs of drying are highest at 28.6% followed by paddy transportation costs (13.6%) then queuing and milling.

Model Calibration

A comparison of the model basic result has been made with values provided by LPN (Table 2). While there are some significant differences in the overall levels of many variables, each difference may be explained in terms of LPN's treatment of unit cost and revenues or systems for

Table 1. The cost components of the optimal solution for basic model run (1).

Item	(M$)	% to total cost	% to total processing cost
INCOME			
Selling of rice	35,598,992		
COST			
Purchasing of paddy	26,892,293	61.21	
Paddy subsidy	9,190,062	20.91	
Milling	1,352,877	3.07	17.24
Queuing	1,519,952	3.45	19.36
Paddy assembly i-j-k	1,066,241	2.42	13.58
i-k	493,207	1.12	6.28
Rice transportation	712,429	1.62	9.07
Drying	2,241,818	5.10	28.56
Paddy storage	66,291	0.15	0.84
Rice storage	13,151	0.02	0.16
Handling of paddy	381,404	0.86	4.86
NET LOSS	8,330,731		
Tonnes of paddy handled	62,938		

Note: All values are in Malaysian ringgits (M$).

Table 2. Basic model results versus LPN records (M$).

Item	Model	LPN	Model –LPN (difference)	% difference
INCOME				
Selling of rice	35,598,992	22,943,092	12,655,900	35.55
COST				
Purchase of paddy	26,892,293	26,764,013	128,280	0.48
Subsidy payment	9,190,062	9,190,062	-	-
Milling cost	1,352,877	1,272,159	80,718	5.96
Drying cost	2,241,818	1,856,657	385,161	17.18
Handling cost	381,404	440,510	– 59,106	– 15.49
Paddy transportation cost (i-k-k)	1,066,241	1,428,017	– 361,776	– 33.93
Paddy transportation cost (i-k)	493,207	n.a.		
Rice transportation	712,427	n.a.		
Queuing cost	1,519,952	n.a.		
Paddy storage cost	66,291	n.a.		
Rice storage cost	13,151	n.a.		
Commission	Not considered	835,460		
NET INDUSTRY LOSS	8,330,731	n.a.		

Notes: 1. i-j-k = Transportation of paddy from field (i) to procurement centre (j) to mill (k).

2. Commission paid by LPN to procurement centres for buying paddy on behalf of LPN.

3. n.a. = not available in LPN records.

assigning deliveries to mills, which are not necessarily based on least cost considerations. For example, LPN do not include figures for depreciation in their cost accounting records which distort their processing and drying cost figures. These comparisons do add confidence to initial expectations that the activity variables in the 'base' run are capturing the 'real' situation.

Assessment of Alternative Bulk Handling Systems

The following options for introduction of bulk handling were analysed using the model.

(i) Semi-bulk system: bulk handling facilities are introduced at the procurement centres. Farmers bring paddy to the procurement centres in the traditional bagged form, but the paddy, once accepted, is placed in bulk facilities and subsequently transported to the mills and processed at the mills in bulk form. This is referred to as the semi-bulk system, because the field to procurement centre stage is still based on the traditional method.

(ii) Semi-bulk system with improved recovery: under this system procurement centres are introduced. A slight improvement in the rice recovery rate from 65 to 66% results from additional drying facilities.

(iii) Complete bulk handling system: bulk handling facilities are introduced in the field itself. Paddy is then transported from the field direct to the mills in these bulk facilities, bypassing the present system's paddy procurement centres.

Appraisal Methodology

The following methodology was used to analyse each form of bulk handling system outlined above. Firstly, appropriate key coefficients in the model were modified. These key coefficients relate to handling cost, queuing cost, different moisture levels at different points in the system, and the rice recovery rate. Secondly, the model was run and the net industry return obtained was compared to the industry return for the basic run. Thirdly, a conventional cash flow analysis was done to determine if the proposed change is viable, assuming unavoidable capital costs are required to be invested in order to make the change.

Optimal model solutions for each bulk handling system discussed above are contained in Table 3. The solutions reveal that annual net industry losses can be minimised by adopting a semi-bulk system including drying at each procurement centre. Installation of drying facilities at these satellite locations is expected to boost recovery rates, thereby requiring less paddy to be handled through the system to supply the predetermined levels of rice demands. In addition to the economic gains indicated in Table 3, the viability of the semi-bulk option may be further enhanced by the following:

(i) Possible improvement in grades of rice produced as a result of improved drying and handling. For Peninsular Malaysia as a whole, it was reported (LPN 1986) that the average percentage of low grades of rice produced is 30%. A smaller percentage improvement of lower grades would occur as a result of improved drying and handling using semi-bulk facilities. This can lead to a considerable reduction in net industry loss.

(ii) In the specification of the model, only 62 938 t of paddy at 22% moisture content pass through

Table 3. Optimal solutions for semi-bulk, semi-bulk with drying facilities and full-bulk systems.

Item	Semi-Bulk		Semi + Drying		Full-Bulk	
	(M$)	%	(M$)	%	(M$)	%
INCOME						
Selling of rice	35,598,992		35,598,992		35,598,992	
COST						
Purchase of paddy	26,892,293	62	25,791,843	62	26,892,293	64
Subsidy payment	9,190,062	21	8,813,920	21	9,190,062	22
Milling cost	1,352,877	3	1,297,524	3	1,352,877	3
Drying cost	2,241,818	5	2,323,336	5	2,241,818	5
Handling cost	62,938		60,263		62,938	
Paddy transportation	1,761,939	4	1,650,413	4	1,422,056	3
Rice transportation	714,638	2	710,943	2	714,250	2
Queuing cost	881,129	2	845,073	2		
Paddy storage cost	18,814		18,815		66,291	
Rice storage cost	15,189		15,189		15,189	
TOTAL COST	43,131,697		41,527,418		41,955,537	
NET INDUSTRY LOSS	7,532,705		5,928,426		6,356,545	
Tonnes of paddy handled	62,938		60,362		62,938	

Note: the percentages were calculated on total cost.

the system. The Tanjung Karang processing system handles more than twice that amount per year and the capital cost figures used in our cash flow analysis were based on the actual flow. If the model was respecified to handle a larger volume, the savings accruing from the introduction of semi- bulk system with improved drying would be increased.

(iii) There would also be some saving in jute cost, at the rate of about 60 Malaysian cents/t.

Analysis of Changes Required for Conversion to Bulk Handling in Tanjung Karang

A detailed assessment of changes required in both infrastructure and investment by all participants in the postharvest system was conducted by the Engineering Division of LPN. These additional costs amount to approximately $M27 million. At harvest time in Tanjung Karang there is a severe labour shortage so that bulk handling will probably have the impact of relieving labour shortages and reducing demand for labour. Consequently there are no social costs of displacing labour through the proposed technological change. Given existing wage rigidities there is not likely to be any general lowering of wages in the postharvest system, as bulk handling will require a higher skilled labour force. On balance the impact of bulk handling will be neutral on the labour market resulting in fewer employees but a much higher skilled and better paid labour force.

The major cost savings in the introduction of a full bulk system from the fields to the mills will be through reduced handling costs in the field, at procurement centres and at the mills. These savings amount to about $42/t of paddy. In addition a faster more efficient delivery system will reduce procurement times and delays in the current system such that postharvest losses are reduced. In the full bulk system it is anticipated that postharvest losses will be reduced by 2% and for the semi-bulk system by a reduction of 1%. Recovery rates for both systems will increase by 1%.

Capital Investment Requirements

The capital cost required under the full-bulk system, including infrastructure changes in the field layout to cater for the bulk handling vehicles, is approximately $M26.8 million. The gain in net industry return is only about $M3 million. The capital cost required to convert the existing system to a semi-bulk system with improved drying facilities at the procurement centres is about $M16.3 million estimated by the Engineering Division of LPN.

Cash Flow Analysis

A conventional cash flow analysis was conducted assuming the levels of capital requirements reflect the full extent of changes required to implement each system. The net present value (NPV) of each handling system at various interest rates is contained in Table 4. The main result of the study is that the introduction of semi-bulk handling facilities, with improved drying, at current paddy procurement centres is an economically viable proposition. The internal rate of return on this investment is 13.72%. The lower IRR value of 8.14% for the full bulk-system stems from the higher capital costs required to implement this system.

Other Factors

The existing postharvest handling of paddy in Tanjung Karang is traditional even though large, modern mechanical harvesting equipment was introduced to the region some 10 years ago. Results of this analysis clearly show the feasibility of introducing a full-bulk postharvest handling system. However, due to the presence of constraints at the farms and procurement centres, this economically attractive proposition may not be socially and politically acceptable. The introduction of bulk handling from the procurement centres to the mills may become the next best alternative in the near future.

Sensitivity Analysis

The optimal solution for the model (semi-bulk handling) system in this region was subjected to a wide range of parametric tests to ascertain the extent to which the preferred option would change as a result of a change in any particular variable. The results of these analyses are given in Table 5. The main conclusions from this series of experiments may be summarised as follows:

(i) Changes in drying and milling costs have minimal impact on the optimal solution as these costs are only about 5% of total costs.

(ii) Changes in the price of both rice and paddy have major impacts on industry net returns. This indicates the importance of pricing policies at all levels in the postharvest chain.

(iii) The impact of recovery rate and the critical importance of paddy drying relative to other postharvest activities is highlighted.

(iv) Initial experiments with alternative patterns of industry organisation serve to indicate that there is considerable potential to reduce industry costs and to improve efficiency through plant closures and amalgamations and rerouting paddy receivals to more economic procurement depots.

Evaluation of Commercial Viability of Satellite Drying Complexes

The implementation of bulk handling not only includes bulk handling equipment for loading, transport and unloading but also provision of bulk storage and drying equipment at procurement depots. To this end the commercial viability of establishing a drying/storage complex based on the combination method of drying wet grains was appraised. The proposed facility analysed by Omar and Ryland (1987) had the following features:

(a) large capacity dual diesel/rice hull fired continuous flow dryer with tempering facilities;

(b) aerated bulk storage with provision for recirculation of the grain;

(c) monitoring equipment for controlling the drying process and for detection of moisture movement; and

(d) equipment for carrying out pest management procedures on a regular basis.

Most if not all of these facilities are currently available at large centralized LPN complexes but not yet available at procurement centres. While bulk storage of grains at many complexes in Malaysia has not been successful, it is believed that the main reason for its slow rate of adoption is the fact that handling of wet grains in a humid environment requires special treatment and a range of strategies to dry the wet paddy quickly and efficiently. The combination method of drying

Table 4. NPV for different discount rates.

Discount rate	Semi-Bulk	Semi + Drying (M$)	Full-Bulk
0.08	7,835,136	23,586,184	27,585,518
0.09	7,284,816	21,929,550	25,647,981
0.10	6,794,045	20,452,176	23,920,100
0.11	6,354,942	19,130,342	22,374,132
0.12	5,960,810	17,943,881	20,986,492
IRR	– 0.12%	13.37%	8.14%

Note: a gain of M$835 460 was included in the calculation of NPV and IRR for the full-bulk system, derived from the non-payment of commission to procurement centres. There is no need for procurement centres in the full-bulk system.

Capital costs required for infrastructural changes for:

(i) semi-bulk system – $16,280,000

(ii) semi + drying system – $16,280,000

(iii) full-bulk system – $26,748,200

Table 5. Sensitivity results.

Item	Run 1 Drying Cost Change (M$)	%	Run 2 Milling Cost Change (M$)	%	Run 3 Recovery Price Change (M$)	%	Run 4 Recovery Price Change (M$)	%	Run 5 Recovery Rate Change (M$)	%
MAGNITUDE	10% Reduction		10% Reduction		10% Reduction		10% Reduction		10% Reduction	
INCOME	35,598,992		35,598,992		35,598,992		32,039,092		35,598,992	
% of change in objective function (income)	– 3.92		–2.25		–41.57		60.04		11.56	
COSTS										
Purchase	25,791,843	62	25,791,843	62	23,327,100	59	25,791,843	62	26,199,273	62
Subsidy	8,813,920	21	8,813,920	21	8,813,920	22	8,813,920	21	8,953,920	21
Handling	60,362		60,362		60,362		60,315			
Paddy transportation	1,646,873	4	1,646,873	4	1,650,413	4	1,650,413	4	1,624,195	4
Rice transportation	710,943	2	710,943	2	710,943	2	710,943	2	710,073	2
Paddy storage	18,815		18,815		18,815		18,815		68,517	
Rice storage	15,819		15,819		15,819		15,819		27,699	
Drying	2,091,002	5	2,323,336	6	2,323,336	6	2,323,336	6	2,357,260	6
Milling	1,297,524	3	1,167,771	3	1,297,524	3	1,297,524	3	1,352,883	3
Queuing	845,073	2	845,073	2	845,073	2	845,073	2	858,421	2
Total cost	41,291,544		41,394,125		39,062,675		41,527,418		42,212,681	
NET LOSS	5,795,133		5,696,092		3,463,683		9,488,326		6,613,689	
Tonnes of paddy handled	60,362		60,362		60,362		61,362		61,315	

Notes: 1. Percentages were calculated using total cost as the denominator.
2. The changes above were made one at a time, using the semi-bulk system as the starting base.

and storage developed by Driscoll (1985) integrates both rapid drying facilities with slower gentler drying in store. Rapid or primary drying at high temperatures removes surface moisture from the grains. High temperatures (60-80°) at high moisture levels (>18%) does not affect grain quality. To remove bound moisture requires lower temperatures and cooling phases to prevent fissuring and cracking of grains. The process of secondary drying is slower and gentler than primary drying particularly as moisture content is stabilised at safe levels.

Drying Costs

The annual costs of operating a drying/storage complex with a 10 t/hour dryer and 1000-t bulk storage are summarised below:

Energy costs	450	0.45
Labour costs	120	0.12
Repairs and maintenance	150	0.15
Total	720	0.72

Given the operating costs assumed above and capital costs of around $M1.3 million, a conventional cash flow analysis was conducted on the performance of the complex assuming a range of drying/storage fees that the complex would need to charge in order to remain a viable investment. The fees charged should be in line with penalties or discounts applied to the wet paddy so that the extra revenue received is just sufficient to offset the extra costs incurred.

Proposed Drying Fees

The deduction rate for moisture in wet paddy currently applying in Malaysia does not cover the costs involved in drying the paddy (Chew and Arshad 1986). For example, at 20% moisture content, 8 kg is deducted per 100 kg which, for grade A paddy, is worth approximately $M5. The average deduction applying for wet paddy throughout the whole ASEAN region at the same 20% moisture content is more than twice this figure at around 16.4 kg/100 kg which is worth around $M10. The drying fee based on this deduction is $M1.66/kg m.x. In other words suppliers of wet paddy would be willing to bid up to $1.66 for each kilogram of moisture removed to be no worse off in the absence of drying. At this fee level suppliers are indifferent between drying and accepting the discounted value of the wet paddy. However, if fees are less than this level then suppliers as a group will be financially better off than at present.

Commercial Viability of Drying

This fee structure was used to analyse a range of different fees and to test the sensitivity of various pricing options. The price received by the satellite drying/storage centres must be sufficient to meet all interest payments and their opportunity costs as well as depreciation, management fees and contingencies. While internal rates of return appear reasonable, the economic returns after providing for interest payments, depreciation and management expenses including contingencies are around 10% when fees are set at $M1.45/kg m.x. A rate of return of 10% is considered satisfactory given the inherent risks involved in investments of this type. The rate of return is very sensitive to changes in fees, electricity charges and volume of paddy handled. A sensitivity analysis of the rate of return to changes in each of these parameters was also conducted. For example, at $M1.45/kg m.x. rates of return could double from 10% to more than 21% if electricity charges could be reduced from $M0.25/kWh to $M0.15/kWh. At the same fee level, returns rapidly decline with throughput such that at around 80% of capacity utilisation (8000 t) returns are negative.

Profitability of Satellite Drying

From the above analysis it was concluded that normal profits may be earned at high capacity utilisation rates given the current electricity charges. Fees which cover these costs are well below marginal returns from paddy of reduced moisture content. Putting the matter another way, the analysis reveals that mechanical drying/storage is a commercially viable activity in ASEAN provided that administrators recognise that drying/storage fees should be based on extraction performance and that returns per unit should offset full economic costs (including finance costs).

Policy Implications

Background

At the outset of this study, Malaysian authorities involved in the administration of the rice/paddy industry recognised the need to include an examination of grading and quality control systems along with the potential for introducing improved technology such as bulk handling. The results of this study reveal that the payoff from policy changes in relation to procurement policies of paddy is many times higher than the payoff to investment in technical change. It has been revealed that the major constraint to the adoption of improved technology is the existence of a paddy procurement and pricing system that distorts the incentive for farmers to produce higher quality paddy. The problem of inferior quality paddy resulting from this system is made worse by the lack of capacity in both private and public receival systems to dry the wet paddy quickly and efficiently. This contributes to the high social wastes of paddy, low recovery and large percentage of low-quality rice all of which contribute to the high net social losses of the paddy and rice industry.

Contemporary Development Issues in Grain Handling

Ryland (1986) discusses six core contemporary development issues critical to any empirical application of transportation production allocation models, if these models are to be relevant for policy and investment planning purposes of grain handling and transportation in the humid tropics. These issues are :

- the role of raw material and commodity pricing policy;
- storage policy;
- quality analysis;
- centralised versus a more dispersed pattern of grain handling facilities;
- the level and extent of public ownership of facilities; and
- intersectoral linkages.

In Malaysia the government intervenes directly to support domestic rice production with a range of input and output subsidies. These distortions in the procurement result in resource misallocation at the producer level to the detriment of the entire food handling and distribution system. Quite clearly this application of the model demonstrates that there needs to be a change in the procurement policy for paddy if improved methods of grain handling and a more rational strategy for investment in grain handling facilities are to be introduced in Malaysia.

The model developed in this study can also be extended to consider other relevant core issues. For example, Champ and Ryland (1986) have provided a conceptual framework for quantifying the expected benefits of improved grain storage systems through the inclusion of not only the production aspects of reduced losses but also qualitative aspects using the implicit price models of Ladd and Suvannunt (1976).

Commercial Investment Opportunities

Opportunities for private sector involvement in the paddy/rice postharvest subsector in Malaysia are limited despite the need for industry restructuring and rehabilitation of facilities. The significant reduction in private capital investment in the industry reflects the lower returns from investment in the rice industry relative to other sectors. Any move towards a freer deregulated marketing and procurement system which properly reflects the resource costs involved in improving efficiency will have significant payoffs in terms of restoring investor confidence and in providing investments which are commercially viable. In this environment the introduction of any form of improved bulk handling technology will proceed rationally without the need for specific further assistance measures. Furthermore it is believed that most of the benefits of an improved system such as bulk handling will be lost, if its introduction is not also coincident with the introduction of a more efficient and effective procurement and pricing system for paddy.

Structural Adjustment Measures

In order to facilitate structural adjustment at both farmer and miller level there needs to be a clear, coherent and consistent program of structural adjustment whereby farmers and private millers can be assisted either to improve the efficiency of their enterprises or to be adjusted out of production in the most equitable manner. Farmers and millers who request assistance would be assessed on the extent to which their enterprises will remain commercially viable in the long term. Those farmers and millers who are assessed to be nonviable will be assisted out of the industry. On the other hand, farmers and millers who are assessed to be commercially viable would be eligible for a range of assistance measures designed to improve their efficiency.

Forms of Assistance

Farmers and millers who are assessed to be commercially nonviable in the long term could be eligible for a range of income support measures. These measures could provide compensation for those eligible farmers and millers who decide to leave production entirely. Compensation could be in the form of an annuity based on the annual lease value of their enterprises or an equity interest in the enterprise that remains. Short-term direct income support could also be available for eligible applicants undergoing assistance. This form of income support measure could gradually replace the existing paddy price subsidy and would target those participants in the rice industry who are in most need of assistance.

Farmers and millers who remain in the industry could be assisted with a range of technical and financial measures of support. Under this scheme, LPN for example, could provide a comprehensive technical extension service to provide advice and assistance to improve the efficiency of the private milling sector. Eligible millers and farmers could also receive a range of measures designed to facilitate adoption of modern grain handling technology in both the field and the mill. The main form of assistance would be an interest rate subsidy on capital investment in farm and mill improvement which would be regularly reviewed and adjusted to market rates as conditions permit.

Income support and interest rate subsidies are a more efficient and equitable means of providing assistance to the rice industry in Malaysia than the existing price subsidy on paddy production. Furthermore, these measures will facilitate resource movement in the entire rice industry and much needed structural change if the industry is to remain commercially viable in the long term. In this economic environment it is believed that the Malaysian rice industry will be able to satisfy the needs of the Malaysian community for higher quality rice at lower prices than what could otherwise be achieved in the absence of any changes.

Future Research Needs

Introduction

This analysis has identified a number of areas where there are potentially significant returns from future economic research. In particular the study has shown empirically that there are potentially greater payoffs from changes in policy than changes in technology. More importantly perhaps the creation of an appropriate economic environment will stimulate (other things being equal) investment in autonomous technical change by private investors. In this framework, the role of the economist is not only to advise on the creation of an economic environment in which future changes can proceed rationally and efficiently but also to provide government with the projected consequences of any change in policy such as the distribution of benefits among all participants in the postharvest system.

Constraints on Development

There are a number of economic and social constraints that impede the implementation of a more effective and efficient postharvest system. Government itself must be held responsible for the consequences of its own actions in intervening in the Malaysian rice industry on the pretext of correcting anomalies and market failure in the procurement of paddy. As Arshad (1982) has shown in an objective analysis, there was little or no evidence of exploitation of Bumiputra farmers by private (mainly Chinese) millers in paddy procurement. It is the intervention of government itself that created the market failure in the procurement system. Consequently it is now up to the government to provide a number of policy measures and instruments that facilitate rehabilitation of the Malaysian rice industry, and structural adjustment particularly for those farmers and millers who are assessed to be commercially nonviable in the long-run.

The agenda for future economic research in the Malaysian rice industry should include the following areas:

- structural adjustment mechanisms;
- grain marketing and quality;
- storage and import policy of rice in Malaysia; and
- evaluation of economic threshold levels of grain/drying and storage and pest management.

Each of these research areas will be described briefly below.

Structural Adjustment Research

Mechanisms and policy instruments that may be used to facilitate structural adjustment in the paddy and rice industry in Malaysia would be evaluated in terms of their cost effectiveness in meeting government targets. Broadly the objectives of this research would be to:

(i) identify paddy farmers and private millers who are judged to be commercially viable in the long term with sound prospects of success if their resource base was improved;

(ii) analyse alternative forms of assistance for facilitating structural adjustment out of agriculture for those farmers and millers assessed to be commercially non-viable in the long term;

(iii) develop criteria which may be used to identify paddy farmers and millers who are 'at risk';

(iv) identify appropriate institutional changes required to implement the structural adjustment program; and

(v) evaluate in net social benefit/cost terms alternative forms of assistance and constraints on their successful adoption.

Storage Policy of Paddy and Rice in Malaysia

The choice of location, product type (paddy or milled rice), quantities to import, store, and technological improvements in grain handling transportation and storage would be analysed using a model of the entire Malaysian rice and paddy economy. Demands for rice of different grades in each region would be estimated as well as supply functions for paddy based on area yields and paddy supply prices. The model would show the extent to which rice will move from surplus regions to deficit regions for maximising net social welfare as well as optimum locations/product type and time period in which storage will be required to satisfy strategic requirements as well as price stabilisation objectives. The aims of the project would include:

(i) development and specification of a space/time/form equilibrium model of the paddy and rice sector in Malaysia in which paddy prices, rice prices, storage and import demand and supply qualities are endogenous;

(ii) calibration of the model for a particular harvesting season;

(iii) use of the model to evaluate alternative storage policies for rice and paddy and import policies for rice for a range of equilibrium values for supply prices of paddy and demand prices for milled rice; and

(iv) use of the model to make recommendations on storage and movements of rice in Malaysia with different policy scenarios for storing paddy and importing rice.

Rice Marketing and Quality

An empirical model based on the conceptual framework of implicit price models for evaluating the impact of quality changes on consumer preferences would be developed. Data on consumer preferences for the different grades of rice would be collected using consumer panels at different consuming locations in Malaysia. Observable product characteristics would be estimated using the empirical model. The implicit prices will be used to evaluate the relative consumer preference for each product characteristic. The analysis would indicate the extent to which the inherent product characteristics influence consumer prices. This information can then be used for establishing different grades. The broad objectives of the project would be to:

(i) identify those product characteristics that exert a strong influence on consumer preferences for rice;

(ii) assess alternative grades and standards and the impact these changes will have on retail sales of rice; and

(iii) recommend changes in grades and establish guidelines for establishing retail prices.

Evaluation of Economic Threshold Levels in Grain Storage Management

Economic threshold levels of grain drying strategies, storage requirements and pest management methods would be evaluated. Models of pest management and grain drying for a range of alternative strategies would be subject to economic analysis to assess the optimal strategy. A model of the entire grain drying/storage/pest management system will be developed and an optimal system will be determined for a range of alternative sizes of establishments and operating conditions. The objectives of this project would include:

(i) developing models for analysing economic threshold levels of pest management, grain drying strategies and storage;

(ii) using the model to design a grain drying/storage system for a range of plant sizes and seasonal characteristics; and

(iii) using the model to design optimal systems for a range of operating conditions.

Conclusions

In this study of the postharvest subsector of the Malaysian paddy and rice economy, an attempt has been made to tackle the problems of handling wet paddy in a humid tropical environment. Postharvest losses attributed to the current postharvest system for handling paddy in Malaysia amount to around 18% annually or a social cost of approximately $M160 million annually. The analysis has revealed that the major constraint on improving the postharvest system in Malaysia is the existing policy of procuring paddy from farmers. Under this system farmers are provided with no incentive to deliver higher quality paddy as the discounts given to farmers for delivering lower quality paddy do not reflect the resource costs involved in cleaning and drying wet grains. On the contrary farmers act quite rationally in delivering lower quality paddy. This market failure in the procurement system is identified as the major constraint to any improved technology adoption.

Policy Constraints

Overwhelmingly the major conclusion is that, however physically impressive the results of any technological change may appear to be, the potential economic benefits will be dissipated unless policy changes are coincident with technical changes. In the absence of any changes in policy, technical changes will be of only marginal benefit to the Malaysian rice and paddy industry. Introduction of bulk handling in both field operations and storage requirements at procurement centres and mills, although technically feasible, are, at best, marginally attractive given the current commercial rates of interest and inherent risks involved in investment in modern grain handling technology. Unless policy changes are forthcoming with respect to paddy procurement, bulk handling in net social benefit/cost terms is only worthwhile within the government storage system itself. Under this system—the semi-bulk system—farmers will continue to deliver their wet, low - quality paddy to procurement centres in government rice complexes as there is no incentive for them to do otherwise. Recovery rates will be low and the quantity of low-quality milled rice available to consumers will only show a marginal improvement. Consumers who prefer higher quality milled rice will continue to have their demands unfulfilled at significant social cost to the whole community.

Information Constraints

Throughout the duration of the research project it became increasingly clear that there were significant data deficiencies throughout the entire postharvest system. Elementary data such as the supply of paddy from each irrigation block, are either based on a crop-cutting trial prior to harvest or by estimation. The data on the marketable surplus should be critical for government decision-making since $M165/t is paid as a subsidy on all paddy produced. The aggregate data are available from government but what needs to be done is for these data after each season to be disaggregated at least to block level. Cost data maintained by LPN do not fully reflect the real resource costs involved. There also needs to be maintained and regularly updated an inventory of new capital investment in the rice industry, particularly in the private sector. In the marketing of milled rice regulation of rice prices, imports, storage requirements and movements of rice are either ad hoc or ineffective which, when combined, add unnecessarily to the costs of the industry.

Opportunities for Development

There needs to be a clear, coherent and consistent set of policies developed for the entire paddy and rice industry in Malaysia if the full benefits of technological improvements are to be achieved. To achieve this goal an agenda for policy research has been proposed which includes policies designed to facilitate structural adjustment and rehabilitation of the industry, to evaluate storage and import requirements for rice and movements of rice from surplus to deficit regions consistent with a net social welfare objective, to analyse rice marketing and quality premiums and to evaluate economic threshold levels for drying wet paddy and pesticide application. More applied economic research and particularly technical research should be targeted towards the private sector as it is believed that the motives and objectives of the state-run grain handling and storage system are not coincident with those of the private sector.

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