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CREDIT, TECHNOLOGY, AND PADDY FARM PRODUCTION: A CASE STUDY OF TANJONG KARANG AND BERANANG, MALAYSIA

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I. INTRODUCTION

THE paddy and rice sector assumes a strategic position in Malaysia. This is due to its importance in the context of self-sufficiency, income generation, and poverty eradication [6].

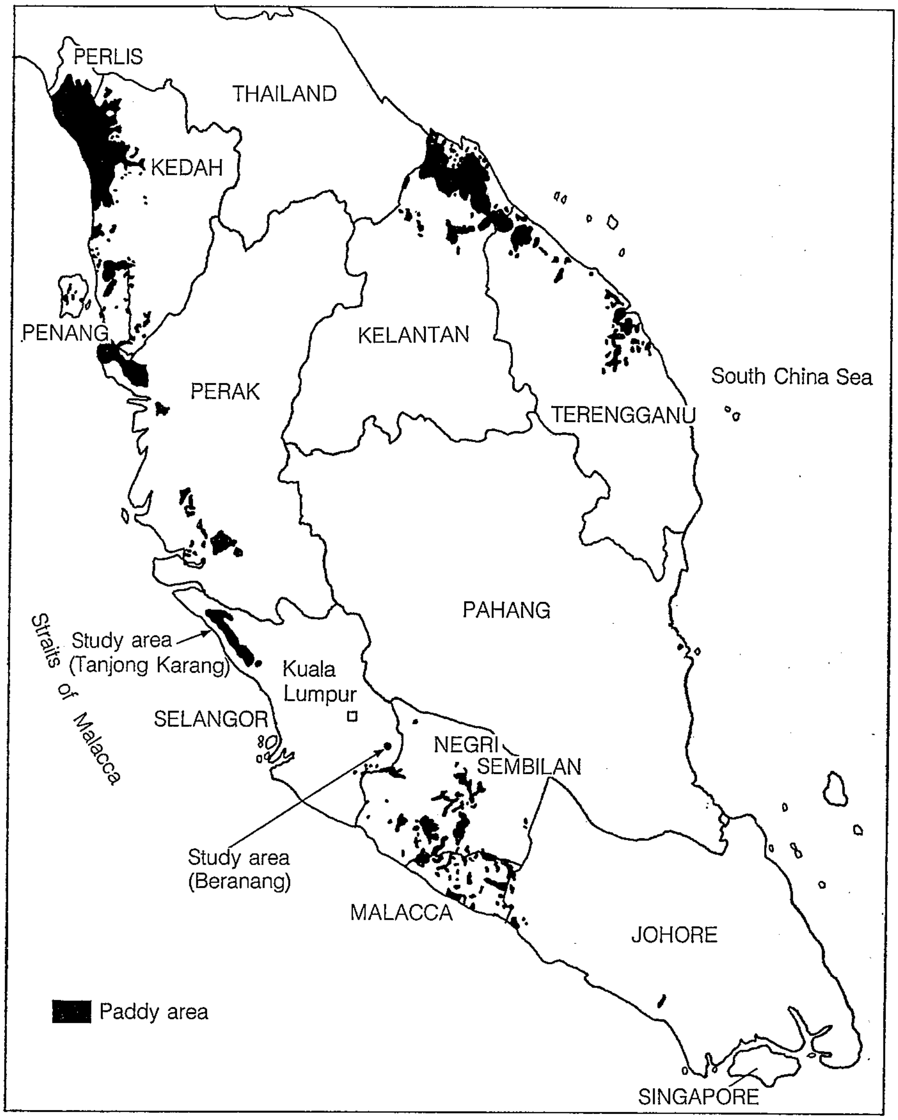
Rice self-sufficiency became a distinct policy goal in the post–Second World War period. From 1949 till the independence in 1957, the overriding objective of the rice policy was the achievement of production targets. The post-independence years saw the continuation of that policy. Three primary objectives of the policy were defined: ensuring food security, raising farm income and productivity, and ensuring food supply to consumers at reasonable cost [7].

Malaysia's paddy and rice policy as it evolved has seen the progressive entrenchment of public sector interest in their production, processing, and marketing. The accent of the policy, however, has shifted from focusing on output goals for self-sufficiency to an intensification of efforts to enhance paddy income. The prevalence of poverty in the paddy sector wherein the Malays predominate explains the continued maintenance of paddy production in an economy in which an efficient agricultural system has all along been central to the maximization of national income [5].

The development and adoption of improved technology is seen as a vehicle for increasing the productivity, output, and income of the paddy farmers [4]. Towards this end various measures including research and development, extension, and training as well as provision of credit have been implemented to encourage the adoption of improved technology. The establishment of Bank Pertanian Malaysia (BPM) in 1969 was aimed, among others, at catering for the credit and financial needs of paddy farmers to acquire the technology [1].

Hitherto, no empirical study has been carried out to analyze the role and impact of credit on technology and production in paddy farms in Malaysia. This has resulted in a lack of knowledge about the relationship between credit and technological innovation as well as their potential role in agricultural development. A study in this area would therefore make a useful contribution and would help fill some of the information gaps.

Fig. 1. Map of West Malaysia Showing Paddy-Growing Areas



The purpose of this paper is to elucidate the impact of credit and technology on paddy farm employment, output, and income based on a case study of Tanjong Karang and Beranang in Selangor, Malaysia. The location of these areas is shown in Figure 1. The findings of this study can provide a useful basis for formulating pragmatic development strategies commensurate with the aims of the national policy.

II. STUDY LOCATIONS

Beranang, which is located approximately 40 kilometers to the southeast of Kuala Lumpur, is characteristically a traditional double-cropping paddy area. It lies within the Hulu Langat Small Irrigation Scheme (SIS). Invariably, the farmers in Beranang are not provided with credit by BPM. This stems from the bank's decision to favor the provision of credit to technologically improved farms particularly those in the "granary" areas. The majority of the farmers in Beranang earn their livelihood by working off-farm.

Tanjong Karang, the other study area, is located about 100 kilometers northwest of Kuala Lumpur, within the northwest Selangor Integrated Agricultural Development Project (IADP). This IADP was established in 1980 and reached maturity stage by 1985. It has now been categorized as one of the sixteen granary areas in the country. The paddy farmers in Tanjong Karang are relatively more advanced technologically compared with their counterparts in Beranang. They also have access to production credit provided by BPM. The two study locations are shown in Figure 1.

III. THE DATA

A sample survey of forty farms in Beranang and eighty-one farms in Tanjong Karang was conducted during the first (main) and second (off) paddy-growing seasons in 1991 to derive statistical data for building up the currently practiced technical, or input-output, coefficients. Ancillary information on prices, costs, and credit was also gathered.

The technical coefficients as well as labor requirements relating to alternative improved paddy-production technologies that are feasible, but not currently practiced, were constructed after consultation with the staff of the northwest Selangor IADP, Area Farmer's Organization, and the Malaysian Agricultural Research and Development Institute (MARDI).

The technical coefficients for the prevailing, as well as feasible, paddy technologies are given in Appendixes A and B, and Appendix Tables I and II. The technologies are ranked in descending order, with the most advanced technology being ranked first (represented by Pd_1 and P_1) and the most inferior technology being ranked last.

IV. THE MODEL

Linear programing (LP) was developed in 1947 by Dantzig [2]. It is essentially a mathematical technique concerned with the solution of simultaneous linear equations based on the process of linear algebra. Given suitably formulated data, LP is capable of producing optimal, mathematical solutions in terms of either maximizing or minimizing some stated objective. The stated objective is subject to linear equalities or inequalities and it assumes nonnegative levels.

Dantzig developed the general LP problem and devised the simplex method for its solution. Since then there has been widespread and rapid progress in the theoretical development and practical application of LP. The theoretical aspect of Dantzig's model has been expanded and refined, such as in the interpretation of duality of LP.

The empirical application of LP to examine the economics of agricultural production was pioneered by, among others, Hazell and Norton [3]. This subsequently led to widespread applications of the technique to farm planning for the optimal combination of enterprises, subject to a particular set of fixed resources, as well as for the least cost method of farm production.

Hazell and Norton's theoretical LP model can be written as follows:

$$\max Z = \sum_{j=1}^{n} C_j X_j,$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, \qquad i = 1, 2, \ldots, m,$$

and

$$X_j \geq 0, \qquad j = 1, 2, \ldots, n.$$

In words, the model sets out to mathematically find the farm plan (defined by a set of activity levels X_j; $j = 1, 2, \ldots, n$) that has the largest possible total gross margin Z, but which does not violate any of the fixed resource constraints, or involve any negative activity levels. The maximization (or minimization) of the objective function, Z, is based on a set of assumptions which relate to the nature of the farm processes, the resources, and activities.

In this paper, a basic model similar to that of Hazell and Norton is initially constructed. The model contains paddy production activities which incorporate both currently practiced and feasible technologies, the land, labor, and capital resource constraints as well as the technical coefficients for the main and off-season.

An extension of the basic LP model is then made to facilitate the analysis of the economic impact of agricultural credit on farm technology and production. This involves incorporating the paddy farms' borrowing decision on the amount of capital requirements to achieve their objective function of farm profit maximization. A short-term capital-borrowing activity for the two paddy seasons is accordingly specified to incorporate the amount of credit obtained and utilized in the farm production. This therefore allows for an assessment of the effectiveness of agricultural credit in generating farm income and employment.

The extension can be briefly described as follows. In the basic LP model for the traditional paddy-growing area of Beranang (BR), a borrowing activity (*BCAP*) and total capital that can be borrowed (*TCAPB*), which represents the credit limit restriction, have been included to facilitate the change in income and employment stemming from varying levels of the borrowed capital resource on the traditional farm. In the case of the technologically advanced paddy area of

Tanjong Karang (TK), the borrowing activity (*BCAP*) and credit limit restriction (*TCAPB*) have been excluded from the basic LP model in order to assess the change in income and employment arising from a hypothetical decrease in borrowed capital on a technologically advanced farm.

The LP model applied in this study to analyze the impact of credit and technology on production, employment, and income is now outlined. The objective function of the model is to maximize net farm income thus:

$$\max Z = \sum_{j=1}^{n} C_j X_j - \sum_{t=1}^{m} W_t L_t - \sum_{p=1}^{q} I_p k_p - \sum_{p=1}^{q} R_p Lr_p,$$

subject to,

$$\sum_{j=1}^{n} A_{uj} X_{uj} \leq A_u, \qquad \text{(land constraint)}$$

$$\sum_{j=1}^{n} b_{tj} X_{tj} \leq N_t, \qquad \text{(labor constraint)}$$

$$\sum_{j=1}^{n} K_{pj} X_{pj} \leq M_p, \qquad \text{(working capital constraint)}$$

$$X_j \geq 0,\ L_t \geq 0,\ Lr_p \geq 0, \text{ and } K_p \geq 0,$$

where

Z = total net income of the farm in Malaysian dollars,
X_j = units of crop produced in acres,
C_j = net income per unit of the crop activity in Malaysian dollars,
L_t = units of labor in hours in period t,
W_t = wage rate in period t,
k_p = borrowed working capital per season ($p = 1, 2$),
I_p = rate of interest,
Lr_p = rentable land per season acre ($p = 1, 2$),
R_p = rent of land per season in Malaysian dollars,
A_{uj} = input coefficient of uth type of land for jth crop activity,
A_u = available quantity of uth type of land per season in acres,
b_{tj} = labor coefficient in period t for jth crop activity,
N_t = available quantity of labor in period t,
K_{pj} = capital coefficient for jth crop activity, and
M_p = available own working capital per season ($p = 1, 2$).

Initially, two basic models are specified. Model BR1 represents a typical paddy farm in Beranang. Model TK1, on the other hand, denotes a representative paddy farm in Tanjong Karang. The impact of credit on farm production is examined by incorporating the capital-borrowing activities in model BR1, and conversely by excluding similar activities from model TK1. These variants are subsequently identified as models BR2 and TK2 for Beranang and Tanjong Karang respectively.

Activities. The activities included in each basic model comprise current and/or feasible paddy-production technologies. Their selection and specification is based on field observation and consultation with the local agricultural officers. Taking into consideration the differences in technology, resource requirements as well as cropping seasons, thirty-eight activities have been specified for model BR1 and fifty-two activities have been identified for model TK1. Of the thirty-eight activities specified in model BR1, twelve refer to alternative paddy-production activities, with each yielding a positive net farm income. There are twenty-six resource-hiring activites, of which twelve are for family labor, twelve for hired labor, and two for rented land. No capital-borrowing activities are evident in this model.

Model TK1 has twenty-four alternative paddy-production activities, each yielding a positive net farm income. The remaining twenty-eight activities represent resource-hiring activities, of which twelve are for family labor, twelve for hired labor, two for rented land, and two for capital borrowing.

In both model TK1 and model BR1 any particular paddy-production activity is considered to be unique if it requires a different level of fertilizers and/or pesticides. Likewise, different cultivation or harvesting technologies are specified, depending on whether these are done manually or mechanically. In order to examine the potential economic implication of mechanical transplanting this activity has additionally been specified in models TK1 and TK2. Also, in these models mechanized dry seeding and mechanized transplanting, which are not currently practiced, have been treated as feasible advanced technologies.

Altogether six technologically specified production activities, each denoted by Pd_i $(i=1, 2, \ldots, 6)$ for each cropping season are specified in model BR1. In comparison, twelve activities, each denoted by P_i $(i=1, 2, \ldots, 12)$ for each cropping season are identified in model TK1. The individual activities are listed in Appendixes A and B.

Restrictions or constraints. The farm production constraints included in both basic models are land, labor, and capital. The rows and right-hand-side values (corresponding to the upper limits of these constraints) as incorporated in the models are given in Appendix Table III. The first row represents the objective function (C), since this is to be maximized there is no right-hand-side value.

Model BR1 contains forty-two restrictions, of which two are for own land, twelve for total labor requirement, twelve for family labor, twelve for total hired labor, two for working capital, and two for rented land.

Model TK1 contains forty-three restrictions. The types of restrictions used in model TK1 are essentially the same as those specified in model BR1 earlier except that it additionally includes a credit limit restriction.

V. RESULTS AND DISCUSSION

The optimal farm plans for the specified LP models, namely, BR1 (traditional technology, without credit), BR2 (traditional technology, with credit), TK1 (improved technology, without credit), and TK2 (improved technology, with credit) are presented in Table I. In this and subsequent tables the monetary values refer to the Malaysian dollar.

TABLE I

OPTIMAL FARM PLANS OF MODELS BR1, BR2, TK2, and TK1

	Traditional Technology		Improved Technology	
	Model BR1 (Without Credit)	Model BR2 (With Credit)	Model TK2 (Without Credit)	Model TK1 (With Credit)
Net income (M$)	1,790.20	3,405.50	2,121.00	5,861.80
Activities (acre):				
Pd_1S_1	1.78	3.91	—	—
Pd_1S_2	1.78	3.91	—	—
P_8S_1	—	—	2.25	—
P_8S_2	—	—	2.25	—
P_4S_2	—	—	—	6.55
P_8S_1	—	—	—	4.42
Total area	3.56	7.82	4.50	10.97
Family labor (hours):				
BFLABDEC	8.93	19.55	40.00	79.56
BFLABJAN	8.93	19.55	126.00	247.52
BFLABFEB	0.00	0.00	18.00	35.35
BFLABMAR	71.43	154.40	6.75	13.26
BFLABAPR	35.71	78.20	6.75	23.26
BFLABMAY	17.86	39.10	105.25	207.74
BFLABJUN	8.93	19.55	42.66	19.66
BFLABJUL	8.93	19.55	130.23	85.19
BFLABAUG	0.00	0.00	17.96	52.43
BFLABSEPT	71.43	154.40	6.74	45.87
BFLABOCT	35.71	78.20	6.74	13.10
BFLABNOV	17.86	39.10	110.00	209.70
Total employment	286.00	622.00	617.00	1,032.00
Rented land (acre):				
LRENT1	0.00	2.00	0.00	0.00
LRENT2	0.00	2.00	0.00	2.13
Total	0.00	4.00	0.00	2.13
Capital borrowing (M$):				
BCAP1	—	356.88	—	338.52
BCAP2	—	356.88	—	1,117.48
Total	—	713.76	—	1,456.00

Note: For an explanation of the symbols, see Appendixes A and B, and Appendix Table III.

The optimal output, as represented by net farm income, of model BR1 amounts to M$1,790, which is derived from activities Pd_1S_1 and Pd_1S_2 using 1.78 acres in each cropping season. Both Pd_1S_1 and Pd_1S_2 refer to wet direct seeding technology, which constitutes the most advanced technology that is feasible in Beranang. This contrasts sharply with the low technology currently being practiced in the area, which is still following transplanting (characterized by technology Pd_5S_1 and Pd_6S_1). What this implies is that despite the wide practice of transplanting in

Beranang there is scope for achieving a higher level of net farm income by adopting the more advanced technology based on wet direct seeding. This technology can and should be introduced.

The optimal plan of BR1 requires 286 hours of labor and M$600 of capital over the two paddy seasons. The land resource has not been fully utilized under this farm plan, obviously due to the lack of capital resource. In this case, therefore, farm capital becomes the limiting constraint to a greater use of the farm area.

In comparison, model BR2, which incorporates a capital-borrowing activity, gives an optimal plan having a net farm income of M$3,405. This income is 90.2 per cent higher than that produced under plan BR1. It can be seen that the optimal plan of BR2 has also been based on activities Pd_1S_1 and Pd_1S_2, as in the case of BR1 mentioned above. The difference, however, lies in the fact that a much larger area is utilized under BR2, thus giving rise to a substantially higher income. In each season 3.9 acres of land is utilized, giving a total of 7.8 acres per year. The improved income derived under plan BR2 therefore stems from this greater utilization of the land resource. The plan uses all of the farmer's owned land which is further supplemented by some rented land.

The optimal solution of model BR2 highlights the potential for increasing the employment opportunities of the farm family labor. The plan requires 622 hours of family labor over the two cropping seasons. This is 117.5 per cent higher than the employment level generated by model BR1. In terms of working capital, the plan requires M$600 of own and M$713 of borrowed capital over two cropping seasons in order to operate the stipulated farm area.

Assuming that the farmers in Beranang can be provided with an average production credit of M$1,456 as currently enjoyed by Tanjong Karang farmers, the optimal farm plan of model BR2 can allow for the utilization of only 49 per cent of the accessible credit. Accordingly, the paddy-production activities based on traditional technology would not fully absorb the credit that can possibly be provided. Thus, in the case of Beranang farmers, the optimal use of borrowed working capital is constrained by the somewhat traditional technology that prevails in the area.

As mentioned earlier, model TK2 is a variant of model TK1 in that it does not include any borrowing activities. The optimal plan of model TK2 generates a total net farm income of M$2,121 based on activities P_8S_1 and P_8S_2 each of which covers 2.2 acres per cropping season. The plan generates 617 hours of employment for the farm family labor. It also requires M$708 of working capital. The available land resources, however, are only partially utilized under this plan.

The level of net farm income and employment generated by model TK2 are 18.5 and 115.7 per cent greater than those of model BR1 respectively. These are also evident from Tables II and III. Therefore, farms which practice improved paddy-production technology can expect to derive better income and employment opportunities compared to those which adopt traditional technology. It can be seen in this study that the paddy farms in Tanjong Karang have tended to derive better income and employment levels than their counterparts in Beranang.

TABLE II
NET FARM INCOME UNDER CURRENT PRACTICES AND ALTERNATIVE OPTIMAL SOLUTIONS

	Net Farm Income (M$)
Model BR1 (traditional technology, without credit):	
Currently practiced income (E)	1,116.00[a]
Optimal plan B	1,790.00
Percent change over E	60.39
Modle BR2 (traditional technology, with credit):	
Optimal plan D	3,405.50
Percent change over B	90.25
Percent change over E	205.20
Model TK2 (improved technology, without credit):	
Currently practiced income (F)	2,838.00[a]
Optimal plan C	2,121.00
Percent change over F	−25.30
Percent change over B	18.49
Percent change over E	90.10
Model TK1 (improved technology, with credit):	
Optimal plan A	5,862.00
Percent change over C	176.38
Percent change over F	106.55
Percent change over D	72.13
Percent change over B	227.49
Percent change over E	425.27

[a] Derived from the field survey.

Model TK1, representing paddy production using advanced technology and supported by borrowed capital, produces an optimal plan having a net farm income of M$5,862 per year. This is based on the adoption of P_4S_2 and P_8S_1. Technology P_4S_2 is a relatively advanced technology based on mechanized dry direct seeding. In the plan it occupies 6.6 acres in the second season, the highest planted area achieved among all optimal plans investigated. On the other hand, technology P_8S_1, which represents an inferior technology based on traditional manual transplanting, is also relevant in the optimal plan of TK1. This technology occupies 4.4 acres in the first cropping season. It is evident that its appearance in the optimal plan has been caused by the inadequacy of borrowed capital to support a more extensive application of the advanced technology of P_4S_2.

Optimal plan A of model TK1 provides for 1,032 hours of employment for family labor in the whole year. It also requires M$708 of own and M$1,456 of borrowed working capital. However, the available land resources are not fully utilized under this plan. Of the 20.8 acres of combined own and rented land available, only 10.9 acres are utilized. In this case, the existing level of BPM credit sets a ceiling on the maximum cultivable area that can be devoted to paddy production.

TABLE III

FARM FAMILY EMPLOYMENT UNDER CURRENT PRACTICES AND ALTERNATIVE OPTIMAL SOLUTIONS

Model	Employment (Hours)		
	First Season	Second Season	Total per Year
Model BR1 (traditional technology, without credit):			
Current (E)	232.00	232.00	464.00[a]
Optimal plan B	143.00	143.00	286.00
Change over E	−89.00	−89.00	−178.00
Model BR2 (traditional technology, with credit):			
Optimal plan D	311.00	311.00	622.00
Change over B	168.00	168.00	336.00
Change over E	79.00	79.00	158.00
Model TK2 (improved technology, without credit):			
Current (J)	376.00	376.00	752.00[a]
Optimal plan C	303.00	314.00	617.00
Change over J	−73.00	−62.00	−135.00
Change over B	160.00	171.00	331.00
Change over E	71.00	82.00	153.00
Model TK1 (improved technology, with credit):			
Optimal plan A	597.00	426.00	1,023.00
Change over C	294.00	112.00	406.00
Change over J	221.00	50.00	271.00
Change over D	286.00	115.00	401.00
Change over B	454.00	283.00	737.00
Change over E	365.00	194.00	559.00

[a] Derived from the field survey.

Overall, model TK1 represents the best paddy-production plan in terms of farm income and employment opportunities. This is brought about largely via the adoption of improved technology in the form of mechanized dry direct seeding method in the second season. In other words, the practice of improved technology, which is facilitated through the provision of BPM credit, has provided the means of achieving greater farm income and employment in Tanjong Karang paddy farms.

VI. IMPACT OF CREDIT

A. *Income*

The net farm income levels achievable under the prevailing production practices vis-à-vis those generated by the optimal plans for Beranang and Tanjong Karang are presented in Table II. Variations in the level of income are evident. In the case of Beranang, the optimal plan of model BR1, which is based on direct seeding in both cropping seasons, generates a total net farm income, of M$1,790. This is 60.4 per cent higher than the income achieved via the transplanting method currently practiced in the area. It appears, therefore, that a shift from the traditional transplanting technology to the improved technology of direct seeding, accompanied by a reorganization of land and labor resources, can bring a higher level of farm production and income.

That a possibility of enhancing the net farm income of traditional paddy farms via credit provision exists is evident from model BR2. Its optimal plan income of M$3,405 is 90.2 per cent and 205.2 per cent higher than the income achievable under the optimal plan of model BR1 and currently practiced situation respectively. The advent of credit induces paddy cultivation on a larger area which in turn generates a greater impact in terms of income generation in these traditional farms.

The optimal plan income of model TK2, for Tanjong Karang, is 25.30 per cent lower than the income derived from adopting the current practices. This reduction in income stems from the lack of credit. However, the income of model TK2 is still 18.5 per cent higher than the optimal plan income generated by model BR1. It is also 90.1 per cent higher than the income generated under current practices of model BR1. This clearly indicates that the adoption of improved technology, even supported only by the farmer's own working capital, leads to a rise in the total net farm income.

It is evident that the availability of credit coupled with the use of improved technology, tends to generate the highest possible net farm income. Model TK1, which incorporates both improved technology and credit, yields a total net farm income of M$5,862 per year. This is 227.5 per cent, 72.1 per cent, and 176.4 per cent higher when compared with the optimal plan income of models BR1, BR2, and TK2. From another viewpoint, the income generated by model TK1 is 425.0 per cent and 106.5 per cent higher than that derived from using current practices of models BR1 and TK2. In this case, the income increasing potential of the farm is actually relatively greater when credit is made available under the improved technology situation rather than the traditional technology situation. In the latter case the full impact of credit on production is curtailed by the prevailing low level of farm technology.

B. *Employment*

The level of farm employment generated under currently practiced and feasible optimal plans may be discerned from Table III. The available farm family labor is estimated to average 372 hours per month in Beranang and 396 hours per month in Tanjong Karang.

The optimal plan of model BR1 provides for an employment opportunity of 286 hours per year for the farm family. This is substantially lower than the employment level of 372 hours observed under the current situation. This finding highlights the existence of disguised unemployment in the traditional paddy-production area of Beranang. It also implies that any reorganization of resources (in farms which practice traditional technology) would not necessarily increase the employment opportunities.

However, with the availability of credit as in model BR2, the utilization of farm family labor is increased to 622 hours. This is 117.5 per cent higher than that observed in the without-credit case of model BR1. Thus, the availability of credit can enhance the employment opportunities for family labor even under a technologically less advanced farm situation. The impact of credit observed under the without-credit situation is shown by model BR1. Thus, the availability of credit can increase the scope of employment opportunities for family labor even in a technologically less advanced paddy-farming situation. The impact of credit is to facilitate the full utilization of both own as well as rented land, thereby resulting in a more intensive use of family labor.

The employment opportunities are greater in those farms that adopt improved technology. Table III indicates that the farm labor requirement of model TK2 is 617 hours per year. This is 331.0 hours higher than that of model BR1. Concomitantly, the optimal labor utilization levels are 82.0 per cent of the level of farm employment currently observed. Evidently, there is still some excess labor and underemployment but this is less extensive than in model BR1. Clearly, a move from traditional to improved paddy-production technology, even without credit, can offer substantial opportunities for increasing the level of on-farm employment and lessening the extent of underemployment.

When credit is provided along with improved technology, the optimal plan generates a significant increase in farm employment. In model TK1, the uses of credit together with improved technology has increased farm employment by 66.0 per cent when compared with the without-credit case of TK2. The optimal plan employment is substantially higher when compared with the traditional technology case of BR1. These findings show conclusively that the adoption of improved technology, supported by production credit, can induce a higher level of activity rate of the farm family labor.

VII. SHADOW PRICES

The dual/shadow price indicates the opportunity cost of resources which have been completely used up [3]. It is calculated for each resource as the cost to the objectives function value if one unit of the resource is to be withdrawn by increasing the corresponding slack activity by an equal amount. The "dual/shadow price" column of Table IV reveals that own farm land in model BR2 has the highest opportunity cost of M$497 per acre in each cropping season. This is followed by model TK1 with M$167 and M$233 per acre for the first and second cropping seasons respectively. Accordingly, an increase of 1 acre of own land will add M$497 to the net farm income in model BR2 and M$167–233 in model TK1. The increase in farm income from bringing in an additional acre of land is much more substantial under the traditional technology.

The own land resource in both model BR1 and model TK2 has zero opportunity cost. Thus, increasing the farmer's own land in these cases will have no effect on the net farm income.

TABLE IV

LP OUTPUT FOR THE ROWS OF MODELS BR1, BR2, TK2, AND TK1

Row	Dual/Shadow Price			
	Model BR1	Model BR2	Model TK2	Model TK1
LANDS1	0.00	497.89	0.00	167.56
LANDS2	0.00	497.89	0.00	233.33
LABDEC	1.00	1.00	1.00	1.00
LABJAN	1.00	1.00	1.00	1.00
LABFEB	0.00	0.00	1.00	1.00
LABMAR	1.00	1.00	1.00	1.00
LABAPR	1.00	1.00	1.00	1.00
LABMAY	1.00	1.00	1.00	1.00
LABJUN	1.00	1.00	1.00	1.00
LABJUL	1.00	1.00	1.00	1.00
LABAUG	0.00	0.00	0.00	1.00
LABSEPT	1.00	1.00	1.00	1.00
LABOCT	1.00	1.00	1.00	1.00
LABNOV	1.00	1.00	1.00	1.00
FLABDEC	0.00	0.00	0.00	0.00
FLABJAN	0.00	0.00	0.00	0.00
FLABFEB	0.00	0.00	0.00	0.00
FLABMAR	0.00	0.00	0.00	0.00
FLABAPR	0.00	0.00	0.00	0.00
FLABMAY	0.00	0.00	0.00	0.00
FLABJUN	0.00	0.00	0.00	0.00
FLABJUL	0.00	0.00	0.00	0.00
FLABAUG	0.00	0.00	0.00	0.00
FLABSEPT	0.00	0.00	0.00	0.00
FLABOCT	0.00	0.00	0.00	0.00
FLABNOV	0.00	0.00	0.00	0.00
OPCAP1	2.98	0.02	2.97	1.90
OPCAP2	2.98	0.02	3.01	1.90
TLRENT1	0.00	372.89	0.00	0.00
TLRENT2	0.00	372.89	0.00	0.00
THLABDEC	0.00	0.00	0.00	0.00
THLABJAN	0.00	0.00	0.00	0.00
THLABFEB	0.00	0.00	0.00	0.00
THLABMAR	0.00	0.00	0.00	0.00
THLABAPR	0.00	0.00	0.00	0.00
THLABMAY	0.00	0.00	0.00	0.00
THLABJUN	0.00	0.00	0.00	0.00
THLABJUL	0.00	0.00	0.00	0.00
THLABAUG	0.00	0.00	0.00	0.00
THLABSEPT	0.00	0.00	0.00	0.00
THLABOCT	0.00	0.00	0.00	0.00
THLABNOV	0.00	0.00	0.00	0.00
TCAPB	—	0.00	—	1.88

Rented land has an opportunity cost of M$373 in model BR2 whereas it is zero in remaining models. This is much higher than the prevailing land rental of M$125 per acre. This implies that the farmers would be better off by renting in land for paddy cultivation.

In terms of working capital, farmers' own capital in model TK2 has the highest opportunity cost at M$3.01 per dollar expended each season, followed by model BR1 at M$2.98 and model TK1 at M$1.90 per dollar. This is greater than the interest rate of 4.0 per cent per annum as charged by BPM.

Model BR2 shows the opportunity cost of working capital to be M$0.02 per dollar which is equal to BPM interest rate. Obviously, the prevailing cost of borrowing is such that the traditional farmers will show indifference to obtaining BPM credit. Lowering the interest rate may induce them to borrow.

It is evident therefore that in each case there will be a beneficial gain by borrowing additional capital. In each of these models the working capital constraint is constructed in such a way that capital borrowed from different sources adds to the working capital initially owned by the farm. Within such a framework borrowing then becomes worthwhile as long as its cost is less than the marginal value product (MVP) of own working capital.

The opportunity costs of family and hired labor in all models are zero, indicating that there is no effect on the net farm income by increasing one unit of labor. It appears that even technologically improved paddy farm production cannot fully overcome the prevailing excess labor problem in both study areas.

VIII. POLICY IMPLICATIONS

The findings of this study clearly show that the application of improved technology is crucial in the striving for higher paddy farm employment opportunities and income. The net farm income of a typical and technologically advanced paddy farm is found to be approximately double that of a representative traditional farm. Likewise, the employment level in the former farm is one and a half times that of a traditional farm.

The achievement of a higher level of farm income via credit provision is effectively realized when this is accompanied by an improvement in production technology. This study has shown that an increase in credit provision under the prevailing low technology has not facilitated any significant rise in farm labor requirement and income. Thus, for paddy farms within the small irrigation schemes such as Beranang the introduction of modern technology becomes a critical factor leading to the achievement of a higher income. Efforts should therefore be intensified to provide extension and training to such farmers. Research and development programs to discover and disseminate improved technology will also need to be further implemented.

In the context of farm technology, the adoption of human resource development (HRD) should be designed and implemented. A large proportion of farmers in Malaysia comprise old, uneducated, and unskilled farmers. This will inevitably impose a severe constraint on development efforts. As such, an upgrading of the skill, technological know-how, and entrepreneurship of these farmers will facilitate both the dissemination and adoption of new technology.

Finally, since this study has shown that technologically advanced farmers tend to rent in additional land, especially with the availability of credit, it therefore appears desirable to promote a rural land bank scheme which can serve as a source from which additional land can be rented. A rural land market should also be established whose purpose is to create an efficient mechanism for land transactions and acquisitions.

From a different viewpoint, there is a need to review the existing paddy-production credit schedule in order to make it commensurate with the technological status and income generation potential of the farmers in the major granary areas vis-à-vis those outside such areas. There is a possibility of the technologically advanced farmers going into higher technology levels if more credit can be made available. This study has indicated that the most recent, and highly recommended, production technology involving mechanized transplanting has not yet appeared in the optimal plan due to insufficiency of credit. It therefore appears vital for BPM to raise the level of credit provided to the technologically advanced producers.

That the farmers in technologically advanced areas such as Tanjong Karang can repay the greater amount of credit has been clearly shown in this study. The shadow price of the borrowed capital in the technologically advanced paddy area is more than sufficient to cover the BPM interest rate. Indeed, there is great merit for BPM to provide for a progressive pattern of credit whereby the level of credit provided increases with higher levels of technology being practiced. This credit policy is attractive in that it can stimulate the adoption of a higher technology. Nevertheless, the implementation of this credit policy would require an extensive evaluation of technological practices in the entire paddy-growing areas.

This study has also shown that the traditional farmers can still afford to pay for the BPM credit if this is to be made available. In this study the shadow price of capital for the Beranang farmers is equivalent to BPM interest rate of 4 per cent per annum. With the application of higher technology there is every reason to believe that the income can be increased well over and above the interest rate.

Another implication that can be made is that there is possibly a need by BPM to differentiate its credit market. Relatively lower rates of interest can be imposed in the less progressive paddy areas compared to that charged in the technologically advanced areas. This is in line with the ability to pay situation of these two markedly different groups of farmers. As one of the major constraints facing the BPM is its high credit administration costs this policy can help defer these costs. In other words, the higher repayment derived from the progressive paddy areas can be made to compensate for the lower repayment from the less progressive areas. This will also allow for credit to be disbursed to many more marginal, or less advanced, paddy areas in the country.

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APPENDIX A

ACTIVITIES IN MODEL BR1 (TRADITIONAL TECHNOLOGY)

Pd_1S_1: This is based on wet direct seeding technology. Broadcasting and harvesting and harvesting operations are done manually. Less than recommended levels of fertilizer and insecticide are applied.

Pd_2S_1: This is similar to Pd_1S_1 with respect to planting method and input use but differs in method of broadcasting in that it makes use of an Amija seeder.

Pd_3S_1: This utilizes the dry direct seeding method. Its other features are similar to Pd_1S_1. However, it uses relatively more labor as compared to Pd_2S_1.

Pd_4S_1: This is similar to Pd_3S_1 in all respects except that it employs a seed broadcasting technique. It makes use of the Amija seeder for this purpose.

Pd_5S_1: This is based on traditional transplanting method. The transplanting and other farm operations are carried out manually. It is characterized by a low application of fertilizers and chemicals.

Pd_6S_1: It is similar to Pd_5S_1 in all respects except that it employs seed broadcasting. The "Amija seeder" is used for this purpose.

BFLABJAN–BFLABDEC: Monthly family-labor-buying activities.

HLABJAN–HLABDEC: Monthly labor-hiring activities.

*LRENT*1 and *LRENT*2: Half yearly land-renting activities.

APPENDIX B

ACTIVITIES IN MODEL TK1 (IMPROVED TECHNOLOGY)

P_1S_1: This is based on mechanized dry direct seeding using recommended levels of fertilizers, insecticides, and weedicides. All farming operations are carried out by machines (four-wheel tractors, broadcasters, and harvesters). This technologically advanced activity is predominantly practiced in the Sekinchan area.

P_2S_1: This is similar to P_1S_1 in that it uses machinery for almost all farm operations. However, it uses a less than recommended level of fertilizers, insecticides, and weedicides as compared to P_1S_1. It also does not make use of the seed broadcaster. This technology is prevalent in paddy farms outside the Sekinchan area.

P_3S_1: This uses machinery only in land preparation; it does not use any harvester. Harvesting is thus performed manually. The fertilizer and chemical application is relatively low compared to P_2S_1.

P_4S_1: It is similar to P_1S_1 in its use of machinery for all farm operations but differs in the use of inputs. It uses relatively less fertilizers, insecticides, and weedicides.

P_5S_1: This is similar to P_3S_1 in all respects except for its use of two-wheel instead of four-wheel tractor for cultivation.

P_6S_1: This is similar to P_5S_1 in planting method, type of the tractor used, level of fertilizer and insecticide application. It also makes use of the harvester and the seed broadcaster.

P_7S_1: This is based on wet direct seeding, whereby more precise control of water is required. Pre-germinated seeds are used. Field preparation and harvesting operations are mechanized. As in P_6S_1 its fertilizer and insecticide application is low.

P_8S_1: This makes use of the transplanting method which is done manually as in the case of harvesting. However, it uses a four-wheel tractor for ploughing. Its labor requirement is relatively larger than in the direct seeding. The levels of fertilizers and insecticides applied are similar to that of P_3S_1.

P_9S_1: This is similar to P_8S_1 in terms of farming operations and input use; it differs only in the type of tractor use, which is two-wheeled.

$P_{10}S_1$: This is based on mechanized transplanting. Also, it adopts a Tray (Talam) type of nursery. All farm operations are completely mechanized. Recommended levels of fertilizers and insecticides are applied.

$P_{11}S_1$: This is a dry direct-seeding method adopted by a Mini Estate Project in the Tanjong Karang area. All farm operations are mechanized and recommended levels of fertilizers and insecticides are applied. Labor requirements are comparatively low.

$P_{12}S_1$: This is similar to $P_{10}S_1$ in all respects except for the nursery which is essentially of the "Dopag" type.

*BCAP*1 and *BCAP*2: Half yearly capital-borrowing activities.

APPENDIX TABLE I

TECHNICAL COEFFICIENTS FOR ACTIVITIES IN MODEL BR1
(TRADITIONAL TECHNOLOGY)

Activity	Land (Acre)	Working Capital[a] (M$)	Labor Requirement (Hours)	Gross Margin[b] (M$)
Pd_1S_1	1	168.00	80.00	581.25
Pd_1S_2	1	168.00	80.00	581.25
Pd_2S_1	1	218.00	76.00	531.25
Pd_2S_2	1	218.00	76.00	531.25
Pd_3S_1	1	168.00	88.00	581.25
Pd_3S_2	1	168.00	88.00	581.25
Pd_4S_1	1	218.00	84.00	531.25
Pd_4S_2	1	218.00	84.00	531.25
Pd_5S_1	1	183.00	144.00	356.50
Pd_5S_2	1	183.00	144.00	356.50
Pd_6S_1	1	233.00	140.00	306.50
Pd_6S_2	1	233.00	140.00	306.50

Note: S_1 and S_2 denote first and second planting seasons respectively.

[a] Comprises variable cost of seeds, weedicides, insecticides, fertilizers, ploughing, broadcasting, and harvesting. Excludes labor charges.

[b] Gross margin = gross revenue − variable cost.

APPENDIX TABLE II

TECHNICAL COEFFICIENTS FOR ACTIVITIES IN MODEL TK1
(IMPROVED TECHNOLOGY)

Activity	Land (Acre)	Working Capital[a] (M$)	Labor Requirement (Hours)	Gross Margin[b] (M$)
P_1S_1	1	330.25	78.00	853.20
P_1S_2	1	334.41	81.00	932.61
P_2S_1	1	307.28	42.00	475.15
P_2S_2	1	308.00	49.00	484.25
P_3S_1	1	208.00	85.00	487.75
P_3S_2	1	225.00	90.00	540.10
P_4S_1	1	205.00	62.00	585.40
P_4S_2	1	225.00	65.00	725.60
P_5S_1	1	195.00	80.00	586.32
P_5S_2	1	200.00	83.00	678.04
P_6S_1	1	270.00	60.00	641.34
P_6S_2	1	276.50	63.00	674.89
P_7S_1	1	341.00	99.00	592.38
P_7S_2	1	346.35	99.00	631.71
P_8S_1	1	156.00	135.00	599.49
P_8S_2	1	159.00	140.00	619.00
$P_{10}S_2$	1	311.58	90.00	808.75
$P_{11}S_1$	1	418.50	60.00	626.24
$P_{11}S_2$	1	422.67	65.00	644.30
$P_{12}S_1$	1	295.50	78.00	793.70
$P_{12}S_2$	1	299.43	82.00	820.88

Note: S_1 and S_2 denote first and second planting seasons respectively.

a Comprises variable cost of seeds, weedicides, insecticides, fertilizers, ploughing, broadcasting, and harvesting. Excludes labor charges.

b Gross margin = gross revenue − variable cost.

APPENDIX TABLE III

CONSTRAINTS AND REQUIREMENTS FOR MODELS BR1 AND TK1

Row No.	Row Identity	Row Description	Right-Hand Relation	Right-Hand-Side Value		Unit
				Model BR1	Model TK1	
1	*C*	Objective function	N			M$
2	*LANDS*1	Season I land	L	1.91	4.42	acre
3	*LANDS*2	Season II land	L	1.91	4.42	acre
4	*LABDEC*	Labor requirement in December	L	0	0	hrs
5	*LABJAN*	Labor requirement in January	L	0	0	hrs
. . .	. . .					
15	*LABNOV*	Labor requirement in November	L	0	0	hrs
16	*FLABDEC*	Family labor available in December	L	372	396	hrs
17	*FLABJAN*	Family labor available in January	L	372	396	hrs
. . .	. . .					
27	*FLABNOV*	Family labor available in November	L	372	396	hrs
28	*OPCAP*1	Operational capital for season I	L	300[a]	351	hrs
29	*OPCAP*2	Operational capital for season II	L	300[a]	357	hrs
30	*TLRENT*1	Total land can be rented in season I	L	2.0	6.0	acre
31	*TLRENT*2	Total land can be rented in season II	L	2.0	6.0	acre
32	*THLABDEC*	Total labor can be hired in December	L	180.0	140	hrs
33	*THLABJAN*	Total labor can be hired in January	L	180.0	140	hrs
. . .	. . .					
43	*THLABNOV*	Total labor can be hired in November	L	180.0	140	hrs
44	*TCAPB*	Total capital can be borrowed	L	—	1,456	M$

Notes: 1. Model BR1 refers to traditional technology, without credit. Model TK1 refers to improved technology, with credit.
2. N and L mean no limit (restriction) and limit (restriction) respectively.

[a] Assumed.