

RUBBER AND OIL-PALM-BASED FARMING SYSTEM FOR THE SOUTHERN SUMATERA TRANSMIGRATION AREAS¹⁾

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Abstrak

Ketidaksesuaian pola usahatani dianggap sebagai salah satu masalah penting di daerah transmigrasi, khususnya daerah transmigrasi Sumatera Selatan. Sehubungan dengan hal itu, fokus tulisan ini adalah pengembangan pola usahatani untuk daerah tersebut. Kerangka teoritis yang digunakan adalah keterpaduan produksi-konsumsi yang dianalisis dengan *multi period linear programming* dengan horison waktu 25 tahun. Fungsi tujuan adalah maksimisasi aliran surplus kas yang didiskonto; dan kegiatan yang dipertimbangkan adalah beberapa tanaman tahunan, tanaman setahun, kredit, pengembalian kredit, dan tabungan. Kendala yang dispesifikasi meliputi iklim, luas lahan, kemantapan persediaan bahan makanan, kredit, pengembalian kredit, dan kebutuhan hidup minimum. Disamping itu, faktor risiko juga dianalisis secara tidak langsung melalui analisis sensitivitas dan analisis sensitivitas Monte Carlo. Hasil studi menunjukkan bahwa dengan bantuan kredit dari pemerintah, para transmigran dapat mengelola lahannya sendiri, membayar seluruh hutangnya, dan mencapai peningkatan pemenuhan kebutuhan hidup minimum. Hal ini dapat dicapai melalui pengembangan pola usahatani karet dan kelapa sawit. Disamping itu, pola usahatani kelapa sawit lebih menguntungkan namun lebih tinggi risikonya daripada pola usahatani karet.

INTRODUCTION

Transmigration is one of the most important programs of the Indonesian government. This can be seen from the number of families moved, the cost, and the number of agencies involved in the program (Hardjono 1986 and Colchester 1986). During Pelita III, around 500 000 families were moved and during Pelita IV 750 000 families were targeted. In addition, by June 1985 western governments had collectively poured US \$800 million in the program with a further US \$750 million in the pipeline (Colchester 1986).

By 1985 many shortcomings of the program had been admitted with unusual frankness by the government. The transmigration program in Air Sugihan and Central Kalimantan, for example, were officially reported as failures (Hardjono 1977 and Secrett 1986). Some indicators of the shortcomings of the previous program

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are low income and standard of living, difficulties in marketing the products, and a large number of transmigrants returning to their origin (Mangoenpoerojo 1985 and Hardjono 1986). For example, the income per capita of the transmigrants averaged US \$61 per annum, far below the national average of US \$560 per annum.

The cost of the shortcomings could be very significant. Firstly, as a main development program of the government, the shortcoming could be perceived as a government failure in a national scale. Secondly, the opportunity cost of the program is high because these fund could be allocated to other strategic programs such as education, health, and improvement of infrastructure (Hardjono 1977 and Mangoenpoerojo 1985). Finally, one of the consequences of the failures in the past has been serious environmental destruction because the participants left their land uncultivated (Colchester 1986 and Secrett 1986).

There is a general agreement on the causes of the failures. Hardjono (1986), Secrett (1986), and Perry (1985) stated that the causes were poor infrastructure, housing, land quality and preparation, location, provision of inputs, difficulties in marketing the products, and inappropriate farming system.

The main weakness of the previous and existing farming system is food-crop orientation which is not suitable to the transmigration areas (Mubyarto 1985, Nataatmadja 1984, Searle 1987, and Tjiptoherijanto 1985). Moreover, Perry (1985) stated that since the soil type in the transmigration areas was red-yellow podsolic, farming system which was food-crop oriented should not be developed in the transmigration areas.

Several studies such as those conducted by Allison and Epperson (1980), Sudana (1988), and Rosyid and Subagyo (1990) introduced perennial crops as the main commodities in their farming system. However, Rosyid and Subagyo (1990), using a static linear programming model, only analyzed the production side of the farming system. Although Sudana analyzed (1988) both the production and consumption sides, the static model he assumed is not appropriate because the main characteristic of perennial crop based farming system is its dynamic attribute. Using a dynamic model (multi period linear programming model), Allison and Epperson (1980) incorporated annual crops, perennial crops, and livestock in their farming system. However, their model did not include government assistance and capital market (e.g. credit and saving). This may restrict the planting of an appropriate perennial crop area in the initial stages of development (Allison and Epperson 1980).

Following the problem, the objective of the study is to design perennial-crop based farming system which include perennial crops, annual crops, livestock, government assistance, and capital market. The model was estimated by using a dynamic approach within integrated production-consumption framework. In addition, the farming systems are proposed to be implemented in Southern

Sumatera Transmigration areas which is the main destination of the transmigration programs.

THEORETICAL FRAMEWORK

An integrated consumption and production framework was used to represent the farming systems. As indicated by Singh, Squire, and Strauss (1986) and Delforce (1987), most production and consumption decisions of the farmers in less developing countries are interdependent. Several empirical studies such as by Lopes (1986) suggested that integrated production-consumption framework is both theoretically and empirically sounder than that which separately analyzes production or consumption sides. Delforce (1987) concluded that most economic entities in less developing countries are more appropriately studied using an integrated consumption-production framework than separate production framework (firm theory).

To estimate the models, a mathematical programming model is preferable than an econometric model. Firstly, since the objective is to choose an alternative farming system, a normative or optimizing approach such as a mathematical programming model is considered the most appropriate method (Anderson 1972). Secondly, as indicated by Delforce (1987), in estimating an integrated model which include several crops the model specification will be easier if a mathematical programming model is used.

Having selected the mathematical programming approach, a model which is explicitly time dependent (dynamic model) is more appropriate. This is because all agricultural production processes, especially perennial crops, are dynamic (Anderson 1972). Moreover, an annual decision model could be used in the development of a farming system plan but it does not answer the time interaction questions, particularly those related to perennial crops and subsidy allocation (Allison and Epperson 1980).

Amongst various types of dynamic models, a multi period linear programming model (MPLP model) was used to develop the basic model of the farming system. Dynamic programming model employing Bellman's principle of optimality was considered less appropriate in this study. The main reason is that the number of the activities and state variables at any stage which is relatively high is not appropriate with the Bellman's model (Minden 1968 and Kelly 1981).

A MPLP model is considered marginally preferable to a recursive model in this study as the dynamic nature of the perennial crops is expected to be more adequately captured by a MPLP model. This is because a MPLP model can be set up to allow simultaneous use of the information over the entire time horizon, and thus, as Kelly (1981) stated, a MPLP model can provide feedback between decisions

in successive periods. In addition, a MPLP model incorporates backward as well as forward reconciliations while recursive models only enable forward reconciliations.

To summarize, an integrated production-consumption approach was used in this study. The model was estimated by using a MPLP model.

EMPIRICAL MODELS

Some features of the MPLP models developed to analyze the farming systems are elaborated in this section. These features are (i) time horizon and discount rate, (ii) objective function, (iii) activities, and (iv) constraints.

Time Horizon and Discount Rate

For this study, a 25-year time horizon was selected. This is because the perennial crops of rubber and oil palm which are included as alternative activities in the models have an economic life of about 25 years. To reduce the complexity of the models, only the first-five years of the models were specified in detail, namely each year was divided into two seasons (wet and dry season). The remaining 20 years were modelled in four periods of five years each.

Following Brown (1982) and Gittinger (1982), the discount rate was estimated by using equation (1) and (2).

$$c = Dd + Eq \dots\dots\dots (1)$$

$$r = (c - f)/(1 + f) \dots\dots\dots (2)$$

where

- c = cost of capital
- D = proportion of debt finance
- d = effective interest rate on debt capital
- E = proportion of equity finance
- q = opportunity cost of equity capital
- f = inflation rate
- r = facta disconto

Objective Function

Survey in several transmigration areas such as Batumarta, Lahat, and Betung indicate that the objectives of the transmigrants are complex. However, their objectives can be broadly classified as; to raise their income levels and standard of living, to educate their children, to satisfy their social and ceremonial obligations, and to produce enough food for their families.

In formulating the models, the first objective, to raise their incomes, was assumed to be the main objective. Following Flinn, Jayasurya, and Knight (1980), the other objectives were treated as constraints in the models.

In the objective function, the objective to raise income could be expressed in various ways such as maximization of gross revenue, net return, stream of cash surplus, and terminal net worth. Following Boehlje and White (1969), the objective function was specified as maximization of the discounted stream of cash surplus (DSCS).

The incremental cash surplus, represented by incremental saving in the models, is expressed as equations (3).

$$Isave_t = TR_t - TC_t - MSL_t - RPY_t + CRD_t + ITR_t \dots\dots\dots (3)$$

where :

- Isave_t = incremental cash surplus (saving) generated in year t
- TR_t = total revenue in year t
- TC_t = total cost in year t
- MSL_t = minimum standard of living in year t
- RPY_t = credit repayment in year t
- CDR_t = credit or loan obtained in year t
- ITR_t = interest gained in year t.

Thus, DSCS in the objective function can be expressed mathematically as :

$$\text{Max DSCS} = \sum_{t=1}^{25} d_t \times Isave_t + DSV \dots\dots\dots (4)$$

$$d_t = (1/(1 + r)^t) \dots\dots\dots (5)$$

where :

- r = discount rate
- DSV = discounted salvage value which was assumed to be made up entirely of the salvage value of the perennial crops.

Activities

In general, the activities considered within the models can be classified into four categories : production, credit, saving, and credit repayment.

The production activities considered included both perennial and annual crops which are traditionally cultivated in Southern Sumatera, namely, rubber, oil palm, rice, soybean, peanut, corn, cowpea, and cassava. Because of technical problems

faced by the transmigrants and processing factories, it was assumed that the transmigrants will cultivate a single perennial crop, namely rubber or oil palm, and their farming system will be called a rubber-based farming system (RBFS) and oil palm-based farming system (PBFS), respectively. Due to the complexity in modelling, the transmigrants' home lots is assumed fixed. The farming system assumed for home lots was taken from a study of home lots by Ismail and Supriatna (1988).

Following Smallholder Rubber Development Program (SRDP), it was assumed that transmigrants can get credit from the government, especially during the first five year development. It was assumed that the interest rate for credit was 12 percent per annum.

From year six, the transmigrants were assumed to commence the repayment of the credit obtained from the government. It was also assumed that the transmigrants have to pay all their credits (principal and interest) by the end of year 25.

Transmigrants were also assumed to save any cash surpluses in the government local bank. These saving activities are also act cash transfer activities to accommodate cash transfer from one time period to the subsequent time period.

Constraints

In general, the constraints included in the models can be categorized into climatic, land, food security, labour, credit, repayment, and minimum standard of living constraints. Climate is an important constraint on cropping pattern in Southern Sumatera. During the wet season, most crops can be cultivated. Conversely, during the dry season, only cowpea can be cultivated.

Total land available was assumed to be 3.6 hectar. Thus, the total area of annual crops and perennial crops must less than or equal to 3.6 hectar.

Food security is an important objective of the transmigrants, especially during the few years prior to harvesting the perennial crops. To satisfy this objective, a minimum constraint on the area of food crops for the first five years was imposed. Following Allison and Epperson (1980) and Sudana (1988), it was assumed that each transmigrant must cultivate at least 0.5 hectar paddy intercropped with corn and 0.10–0.50 hectar of cassava to satisfy family food requirement.

For the basic model, a constraint of no hired labour was imposed for each season. Based on some previous studies (e.g. Arifin *et al.* (1986), Hendratno and Susila (1986), and Anwar *et al.* (1988), the average family labour was estimated at 626 labour day per annum. Assuming that 107 labour-days of labour was used for home lots activities, total labour available for farming was estimated 519 labour days per year.

There are two main constraints associated with credit, namely the maximum total credit and the total credit per year that the transmigrants can get from the

government. There is insufficient information to estimate the value of these constraints so that they were estimated by using a simulation approach. The repayment constraints were included to keep a tally of the total loan outstanding and ensure all loan was repaid. The same approach as in the credit constraints was used to determine the flow of the repayment.

To accommodate the other objectives of the transmigrants, a minimum amount of cash which must be available per year to satisfy the minimum standard of living was imposed in the model. The minimum standard of living included were a requirement for basic needs, education for their children, and social and ceremonial obligation. Using the results of the previous studies (i.e. Djafar *et al.* (1988), Nancy *et al.* (1985), Hendratno and Susila (1986), it was assumed that at least Rp 1 106 225 would be require per family per annum. Following the increase in household consumption in Southern Sumatera over the last ten years, the minimum standard of living was assumed to increase by 2.5 percent per annum.

Sensitivity Analyses

Since the models are deterministic, sensitivity analyses on some important parameters or constraints, namely the discount rate, the minimum standard of living, labour availability, credit, and the price of the perennial crops, were conducted. By parameterizing the models (i.e. systematically changing the value of a certain constraint) the relationship between DSCS and the value of the constraint was elicited. This relationship was then estimated by using a quadratic model so that sensitivity analyses could be expressed in term of elasticities (see Anderson (1972) and Susila (1991)). In addition, since the price of the perennial crops can not be parameterized, the sensitivity of the models with respect to change on prices was estimated using a form of Monte Carlo sensitivity analysis (see Susila (1991)). Finally, the basic form for matrix for the model is presented in Table 1. As seen in the table, the matrix consists of 79 activities and 83 constraints.

Data Source

The main data source for the study is the Research Centre of Estate Crops Sembawa that has two research station namely Sembawa and Batumarta research station. Three other data sources for the study were Direktorat Jenderal Perkebunan, Biro Pusat Statistik, dan Bank Indonesia.

Table 1. The matrix of the farming system.

Constraints	Activities						
	Production	Family labour	Hired labour	Credit	Saving	Repayment	Artificial activities
	(25)	(10)	(10)	(5)	(9)	(4)	(16)
Land and climate							
Total land (5)	-----						
Intercropped annual crops in dry season (5)	-----						
Intercropped annual crops in wet season (5)	-----						
Minimum paddy and corn (5)	-----						
Minimum and maximum cassava (10)	-----						
Labour							
Family labour in dry and wet seasons (10)	-----	-----	-----				-----
Hired labour in dry and wet seasons (10)	-----	-----	-----				-----
Cash flow and the minimum standard of living (9)	-----	-----	-----	-----	-----	-----	-----
Credit							
The maximum and the flow of credit (4)				-----			
Repayment (3)						-----	
Artificial constraints							
Labour (12)		-----	-----				
Cash flow (5)				-----		-----	

Note: - the number in the brackets indicating the number of constraints or activities
 - artificial constraints and activities were specified to help model formulation and sensitivity analyses (parameterization)
 - -----: indicating that the activities and constraints are linked.

RESULTS AND DISCUSSION

As suggested by McCarl and Apland (1986) and Mihram (1972), the model was verified and validated. In general model validation was done through extensive checking of raw data and data file. Model validation was done through validation by construct and validation by results. Validation by construct was based on the assessment on theories used, important assumption and constraints, and data source and measurement; validation by results was conducted through feasibility experi-

ments and quantity experiments for some crucial variables. In short, the models seem to adequately represent the system being modelled. Although some flaws of the models were identified, most verification and validation results support the realism of the models.

Basic Optimal Solution

The basic optimal solution associated with the production activities are presented in Table 2. As seen in the table, the value of the objective function (DSCS) for the PBFS is higher than that for the RBFS. This is primarily due to the fact that the total area for the oil palm is higher than that of rubber, 1.71 hectare and 2.74 hectare, respectively. Under current prices the profitability per hectare of rubber and oil palm is about the same. Therefore, the DSCS is determined mainly by the total area of the perennial crop.

The difference in the total area of the perennial crops is primarily due to the difference in the age of maturity of rubber and oil palm crops, six and four years, respectively. As seen in the table, for the first three years the total area of perennial crops is similar in both models. However, during the fourth and fifth years, the area of rubber is only marginally increased while the area of oil palm is significantly increased, especially in year five. The reason for this is that oil palm generates some cash in year four and five and thus less annual crop are required to satisfy the cash needed to fulfil the minimum standard of living. This releases resources mainly labour and cash, which can be utilized in the cultivation of more oil palm.

Table 2 also shows that for the optimal solution, the RBFS requires lower amounts of input than the PBFS. The minimum credit requirement of the RBFS and PBFS is Rp 590 000 and Rp 804 000 respectively while the minimum family labour requirement is 247 and 259 labour-days per season, respectively.

Sensitivity Analyses

In general, the models are relatively sensitive to change in the value of the minimum standard of living for the first five year. The solution of the RBFS and PBFS will not be feasible if the minimum standard of living is increased by 0.75 percent and 0.05 percent respectively. This can be explained by the fact that during the first five years, no income is generated by the perennial crops. Therefore, to fulfil the minimum standard of living the transmigrants must rely on their annual crops and home lot activities. If the minimum standard of living in the first five years was increased, the area of annual crops would have to increase, implying a decrease in the area of the perennial crop.

Table 2. Basic solution of the production activities*.

Activities**	RBFS	PBFS
Year 1		
Increase in rubber/oil palm	0.9870	1.0808
Total area rubber/oil palm	0.9870	1.0808
Intercrop peanut and corn	0.4870	0.5808
cowpea	0.9683	0.8457
Total area annual crops	2.0553	2.0265
Year 2		
Increase in rubber/oil palm	0.2685	1.3369
Total area rubber/oil palm	1.2555	1.4177
Intercrop peanut and corn	0.7485	0.9177
cowpea	1.2529	1.1354
Total area annual crops	2.6014	2.6531
Year 3		
Increase in rubber/oil palm	0.1019	1.1575
Total area rubber/oil palm	1.3574	1.5752
Intercrop peanut and corn	0.8423	1.0752
cowpea	1.3548	1.2708
Total area annual crops	2.7971	2.9460
Year 4		
Increase in rubber/oil palm	0.0000	0.1476
Total area rubber/oil palm	1.3574	1.7228
Intercrop peanut and corn	0.8489	0.7291
cowpea	1.3550	0.9723
Total area annual crops	2.7039	2.3014
Year 5		
Increase in rubber/oil palm	0.3548	1.0217
Total area rubber/oil palm	1.7122	2.7445
Intercrop peanut and corn	0.4444	0.6693
cowpea	0.9192	1.1693
Total area annual crops	1.9636	2.4386
DSCS (Rp 000)	14 122	19 288
Minimum credit requirement (Rp 000)	590	804
Minimum family labour requirement (labour-days)	247	259

* : the solution is based on the assumption that the maximum credit that could be obtained by the transmigrants is Rp 804 000.

** : the area of cassava and intercrop between paddy and corn is 0.1 and 0.5 hectare, respectively.

The contrary occurs, especially after year six; both models are relatively insensitive to change in the value for the minimum standard of living. The reason for this is that, by year six, a significant amount of cash is generated by rubber or oil palm.

Both models are relatively insensitive to change in the discount rate. In other words, a large change in the discount rate is required before the current optimum solution changes. For example, by running the model with an increase in the discount rate by 100 percent the solution is still stable.

The sensitivity of the model (the DSCS) to change in family labour and credit is presented in Table 3.

Table 3. The elasticities of the DSCS with respect to credit and family labour.

Input	Elasticity*)	
	RBFS	PBFS
Credit	0.2365	0.1523
Family labour	2.3596	1.9083

*) Computed at mean values.

The DSCS of the RBFS is more sensitive to change in inputs than that of the PBFS. With respect to family labour, for example, a one percent increase in the amount of family labour causes an increase of 2.36 percent in the DACS of the RBFS whereas in the PBFS the increase is 1.91 percent.

The elasticities also show that the DSCS is more sensitive to a change in the amount of family labour than that of credit. This indicates that the marginal value of the family labour is higher than of credit. This is consistent with the previous studies (e.g. Sudana (1988) and Rosyid and Subagyo (1990)) that indicated that labour is the most limiting factor in the transmigration areas, especially in the first few years.

The elasticity value can also be used to derive a quick or dirty estimate of the rate of substitution between inputs. As an illustration, a decrease of a one percent in family labour in the RBFS will decrease the DSCS by 2.36 percent. This decrease can be offset by increasing credit by 9.98 percent. In other words, the rate of substitution between family labour and credit in the RBFS is 9.98.

The rate of substitution between family labour and credit is lower in the RBFS than in the PBFS (= 12.53). This suggests that the role of credit relative to family labour is less important in the PBFS than in the RBFS. This can be explained by the difference in the mature ages of rubber and oil palm. The earlier productive

period of oil palm will lead to earlier additional cash generation in the PBFS so that the importance of cash relative to labour is less in the PBFS and in the RBFS.

Nearly all rubber and oil palm produced is exported and the price for both crops are highly volatile on the world market. Using Monte Carlo simulation of the last ten year prices, the variation in the DSCS as a results of price fluctuation is depicted in Figure 1.

As seen in the figure, the PBFS is more profitable but more risky than the RBFS. The higher profitability of the RBFS is indicated by the higher mean of the DSCS which is Rp 19 551 000 for the PBFS and Rp 17 008 000 for the RBFS. Conversely, the riskiness of the PBFS is indicated by the higher coefficient of variation of the DSCS which is 66 percent for the PBFS and 32 percent for the RBFS. This is indicated by wider shape of the distribution of the DSCS for the PBFS. In addition, no feasible solution would be obtained for the PBFS in 7.2 percent case implying that transmigrants adopting the PBFS would be unable to satisfy the minimum standarfd of living requirement or repay their loans with probability of 0.072.

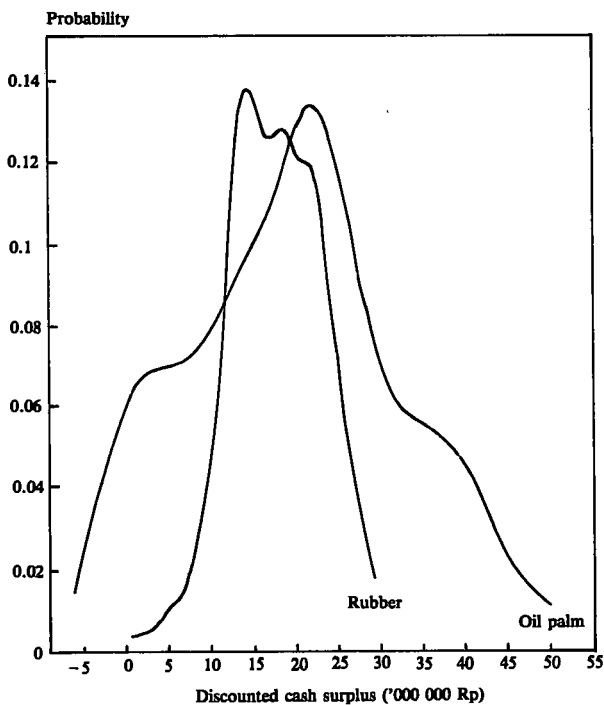


Figure 1. Distribution of discounted stream of cash surpluses with price changes.

CONCLUSION AND POLICY IMPLICATION

With a certain amount of credit, the RBFS and PBFS are two feasible farming systems that can be implemented in the transmigration areas in Southern Sumatera. This indicating that through government assistance, the transmigrants should be able to develop their own land and attain a satisfactory standard of living.

Some characteristics of the RBFS and PBFS are as follow: (i) With the same amount of credit (Rp 804 000), the total area of perennial crops in the RBFS and PBFS is 1.71 hectar and 2.72 hectar, respectively. Following this, the PBFS is more profitable than the RBFS. However, with respect to price, the PBFS is more risky than the RBFS. (ii) The first few years of development are more critical in the PBFS and in the RBFS. The minimum amount of credit required to develop the PBFS is higher than that required to develop the RBFS, Rp 804 000 and Rp 590 000, respectively. The minimum labour required by the PBFS is higher than that required by the RBFS, 258 and 247 man-day per semester, respectively. (iii) With respect to change in the values of inputs, the RBFS is generally more sensitive or elastic than the PBFS. (iv) The importance of credit relative to family labour is less in the PBFS than in the RBFS.

Some policy implications that can be derived from the study are as follow: (i) To facilitate the agricultural diversification policy, the feasibility of the RBFS and PBFS suggests that they should be considered as alternative farming systems than can be implemented in the Southern Sumatera transmigration areas. (ii) In selecting the farming system to be implemented in a particular area, the attitude of transmigrants toward risk should be considered. This is because the PBFS is more profitable but more risky than the RBFS. (iii) Using the elasticities and the rate of substitution between credit and family labour, the government can formulate credit policies most likely to achieve certain objectives, such as improvement in family income or income distribution.

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