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**AN AGRO-ECONOMIC APPROACH  
TO THE  
OPTIMAL ALLOCATION OF LAND  
TO  
RUBBER, OIL PALM & COCOA**

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A thesis presented in partial fulfillment of the requirements for  
the degree of MAgSc in Agricultural Economics at Massey University.

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December 1990

## ABSTRACT

This study details the formulation of a dynamic mathematical programming model for obtaining optimal crop-soil allocation plans for perennial crops. The hypothetical model was built to complement soil survey studies in making land-use recommendations for Malaysian plantations.

The intertemporal linear programming model was constructed to solve the problem of allocating Rubber, Oil Palm and Cocoa to various soil types encountered in Malaysia over a three year land allocation period in such a manner so as to maximize the present value of annual after-tax net income over the crops optimal rotation age.

The framework also treats alternative goals by requiring basic consumption needs be met, and permits borrowings (upto a prespecified limit) and lendings to cover annual negative and positive annual cash balances respectively.

Data input-output coefficients used in model formulation reflect the agro-economic environment in which Malaysian plantations today operate. However, commodity prices forecasted by the FAO for the commodities concerned were used in the valuation of planted assets beyond the three year land allocation model horizon.

The results obtained on computation provide detailed planting plans with respect to the amount of a particular soil type that should be allocated to a crop and the year in which the planting(s) should be carried out. In addition, the amount of labour, fertilizer and capital goods required in any of the three years within the horizon is generated, as is the amount of crop produced and sold. Also, annual income and expenses are automatically allocated to the various tax-brackets in such a manner as to minimize cash lost through taxation.

By making multiple optimization runs, the sensitivity of the optimal plan to changes in the various parameters was also examined.

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**An Agro-Economic Approach to the Optimal Allocation of Land  
to Rubber, Oil Palm & Cocoa.**

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Chapter 1

INTRODUCTION

1.1 Objective of Study

This study addresses the difficulty faced by managers of perennial crop plantations / orchards with respect to allocating their plantable areas to the various perennial (and/or annual) crops.

If a plantation manager's goal is to maximize the financial returns from his land with the various perennial (and/or annual) crops over their individual productive lifetime, he would naturally plant the crop which gives the highest return (in present value terms) from a particular unit of land. This implies settling for lower returns now in exchange for higher returns in the future.

With that stated, it should also be obvious that 'land' or rather the 'productive capacity of land' is not always uniform. Nor is the productive capacity (yield) of the crop uniform (particularly under various soils / terrain and climatic regimes).

Added to this, the generally unstable nature of agricultural commodity prices (largely due to the highly inelastic nature of the Supply and Demand curves of such commodities), one can easily appreciate the difficult choice the plantation manager has to make concerning what to plant on his various soil types under various climatic conditions, so as to maximize financial returns. Making such a 'rational' decision is particularly difficult as the long productive lifetime of perennial crops make it necessary to forecast commodity prices in the distant future accurately, and this is almost impossible to do. It also requires that the decision maker make a preference between consumption in a particular time period versus consumption in a later time period.

It should also be noted that once a land allocation decision for perennial crops has been made and implemented (i.e. the ground has been planted), it becomes too costly to change it. This is especially true for perennial crops that take a long time to mature and/or those that have a very long productive lifespan. Thus, the decision maker cannot afford to make large errors of judgment when arriving at a land allocation decision.

As it is almost impossible to predict crop product prices more than a few years in the future with some degree of accuracy, a decision maker also has to analyze the risks involved (as measured by opportunity costs) in making a 'less than optimal' decision. The sensitivity of the 'rational decision' to various factors that are involved therefore also needs to be studied when arriving at an optimal land allocation plan.

This study aims to provide a theoretical framework (for a normative analysis) by which a plantation manager is able to make 'more rational' decisions concerning what perennial (and/or annual) crops to plant.

The study also tries to illustrate the need for a sensitivity analysis to be carried out so as to assess the degree to which the various factors affect the Optimal Land Allocation Plan. In this way, the risk of making a 'less than optimal' land allocation decision arising from commodity price fluctuations or factor input costs can be assessed.

A sensitivity analysis also allows for various land-use plans to be derived under various financial scenarios and management preferences. The start-up capital available for planting investment, the savings and borrowing rates, which are somewhat more specific to the individual firm, are particularly critical variables leading determining the optimal plan. As such, land-use plans for a range in values of these financial variables should be presented to the decision maker for him to make a choice.

An attempt to forecast future prices of the various perennial crop commodities could perhaps also be made by estimating their supply and demand functions empirically. However, due to time and budget constraints, this aspect will not be covered in this study. The reader is instead referred to Food and Agricultural Organization (FAO) Production Yearbooks where projected prices for various agricultural commodities are provided based on spatial and intertemporal supply and demand models developed by the FAO.

## 1.2 Scope of Study

The use of the theoretical framework will be illustrated on a very real example problem that plantation managers in the humid tropics (such as Malaysia and Indonesia) face - that is, how much of each years plantable area should be allocated to the following perennial crops: Rubber, Oil Palm and Cocoa, given that these areas could consist of different soil types and be located under different climatic regimes.

Of course, these perennial crops also face competition for land from other perennial crops in Malaysia and Indonesia, particularly from the increasingly more important fruit crops as well as from the newly profitable fast-growing forest plantation species.

Although annual crops also compete for land, they cannot generally be cultivated on a large scale in Malaysia or Indonesia as these crops require a rather level terrain, which only exists in small and isolated units.

These other perennial and annual crops could easily be included in the decision making process to be formulated. However, as these other perennial fruit and forest species are relatively new and as relatively little agro-economic information is available, they have not been included in the case study. The annual crops have also not been included as they are almost never considered by plantation managers for the reasons already stated above.

In this study, the illustration of the analysis for rubber, oil palm and cocoa is very general and broad in scope so as to be applicable to most commercial plantations in Malaysia and Indonesia. It is the author's intention and hope that the model developed here can be easily used (with the minimum of modifications) to complement soil survey studies in recommending land-use plans in Malaysia and Indonesia.

To this end, yield coefficients for very diverse soils / terrain and climate types that are encountered in Malaysia and Indonesia, have been derived. The labour and capital coefficients used in the study are illustrative of the Malaysian situation. (Some modifications, especially with respect to labour costs and factor inputs would have to be made to make the model suitable for application in Indonesia).

Outline of Study

Having stated the nature of the land allocation problem faced by decision makers / plantation managers in this **introduction** chapter (Ch 1), the next chapter (Ch 2) will describe in general the **analytical methods** often used to solve such problems and give a brief overview of their advantages / disadvantages as analytical tools. The superiority of using mathematical programming as a tool in solving the land allocation problem (along with its weaknesses / assumption) will however be emphasized, particularly in an intertemporal setting.

Following this, in the next chapter (Ch 3), the **theoretical framework** of an intertemporal mathematical programming model will be developed to solve the problem of allocating land to the various perennial crops.

Before applying the theoretical framework to develop the applied model, a brief review of the agro-climatic factors involved in **crop production** is made (Ch 4). This will allow the decision maker to consider factors other than soil type (such as rainfall, crop susceptibility to pests and diseases etc.) when deciding on what cropping activities are suitable for inclusion into the model in a given locality. The appropriate input-output coefficients with respect to yields, labour and capital can then be derived in order to define the cropping activities when formulating the model.

In addition, a review of the commodity and factor input **markets** is carried out (Ch 5) to give the decision maker some idea of the supply and demand situation, and therefore the commodity prices and input costs that can possibly be expected, both in the short term, as well as in the long term.

Having obtained some indication of crop activity input-output coefficients as well as the long term commodity and factor input prices that can be expected, the **model** is constructed (Ch 6). The computed **results** are presented and interpreted, together with the results of sensitivity **analyses** conducted (Ch 7).

Following a **discussion** on the model's achievements and limitations (Ch 8) the study is closed with a **conclusion** section (Ch 9) suggesting extensions and other possible uses of the developed model.

Chapter 2

ANALYTICAL METHOD

2.1 Capital Budgeting, Marginal Analysis and Mathematical Programming

Techniques commonly used to obtain solutions to capital budgeting, plantation/farm management problems include computing the present value of the expected flow of future net returns, the internal rate of return from that flow, or the minimum payback period for the relevant investment alternatives.

The use of the discounted cash flow technique is however limited, since many types of investments allow for several activities, each subject to their own constraints. Since it is basically a non-optimization technique, it is not really suitable to the problem at hand of determining the optimal allocation of land resources over time to various cropping activities. The technique could only answer this question by running a large number of scenarios to determine the one that would maximize the decision maker's objective.

The need, therefore, is for an optimization technique that can deal simultaneously with many activities and many constraints.

Marginal Analysis and Mathematical Linear (or Quadratic) Programming, which are both optimization techniques and therefore have the ability to overcome such multi-activity problems, are thus more suited to these types of investment analysis. These applications are generally designed to maximize the present value of future incomes over some planning period by striving for an efficient allocation of scarce resources to meet desired objectives. Many problems which have a definite objective with alternative methods of achieving that objective subject to pre-specified restrictions, can be expressed as Lagrangian constrained functions in marginal analysis or as mathematical programming problems.

In either case, the objective may be the maximization of a linear or quadratic profit function (and perhaps the simultaneous minimization of a quadratic risk function). Specification of the problem would include the quantity of resources available, the possible outputs, the quantity of resources required per unit of output, and the profit (or risk) associated with an unit of output. A solution that satisfies both the conditions of the problem as well as maximizes (or minimizes) the given objective, is termed an optimum feasible solution.

Thus the essential difference between capital budgeting, marginal analysis and mathematical programming is that the latter two are optimization techniques, while the former is not.

2.2 A Comparison between Mathematical Programming and Marginal Analysis in optimizing objectives that are subject to constraints.

The Lagrangian technique for solving constrained optimization problems involves optimizing a function which combines the original objective function and the constraint conditions. This combined equation, called the Lagrangian function, is created in a way that insures that:

- when it has been maximized (or minimized), the original objective function will also be maximized (or minimized), and
- all the constraint requirements will have been satisfied.

Suppose we have an objective function of the following form:

$$Y = f(x_1, x_2)$$

which is subjected to the following constraint (with 'n' being the limiting resource):

$$x_1 + x_2 = n$$

then, the Lagrangian will appear as:

$$Z = f(x_1, x_2) + \lambda(n - x_1 - x_2)$$

The maximization (or minimization) of Z can be obtained by taking the first derivatives of Z with respect to the various parameters ( $x_1$ ,  $x_2$ , and  $\lambda$ ), and then solving them simultaneously to obtain the values of  $x_1$ ,  $x_2$ , and  $\lambda$  that maximizes (or minimizes) Z.

Note:  $\lambda$  (the Lagrangian multiplier) indicates the marginal effect on the original objective solution by releasing the constrained resource by one unit.

The Mathematical Programming technique however, does not combine the objective with the constraint function(s) (as the Lagrangian technique does), but keeps them separate and solves them by various optimization routines - graphical, algebraic or by using the Simplex algorithm. It's main advantage over Marginal Analysis lies in it's ability to easily handle numerous constraints and activities.

Both Mathematical Programming and Lagrangian constrained Marginal Analysis do allow for 'non-equalization' in the optimization process so reflecting trade-off's between various constraints. This flexibility is reflected in the Surplus / Slack variables in mathematical programming. Furthermore, the Dual of the problem provides us with the Opportunity Cost (Shadow Price) of the various constrained resources, (as does the Lagrangian technique, where  $\lambda$  is the Shadow Price). In other words, additional resources are utilized only as long as their marginal contribution to the objective function is at least as great as their marginal cost.

Because of the easy handling of numerous constraints and activities in a Mathematical Programming framework (using the simplex algorithm), this was the method of analysis chosen for use in this study to allocate land optimally in the cultivation of perennial crops. Its ability to consider a large amount of capital, agronomic constraints and cropping activities is what makes the technique superior to constrained marginal analysis which does not permit easy computation of more than a few activities and constraints. Furthermore, changes can be easily made to various parameter values and new solutions quickly obtained through the use of mathematical programming.

### 2.3 Assumptions made in Linear Programming Models

A number of assumptions about the nature of the production process, the resources and activities, as well as of the objectives, are implicit in a Linear Programming model. Heady and Candler (1958) define them as:

1. **Continuity** - It is assumed that resources can be used, activities carried out, and objectives met in units that are fractional units.
2. **Homogeneity** - It is assumed that all units of the same resource and activities are identical.
3. **Additivity** - The activities are assumed to be additive in the sense that when two or more units are used, their total output is the sum of their individual outputs i.e. a linear production function is assumed. As such, no interaction effects between activities are permitted in a LP framework.
4. **Proportionality** - The gross margin and resource requirements per unit of activity are assumed to be constant regardless of the level of activity used (as economies of scale cannot directly be modeled in the LP framework). A constant gross margin per unit of activity thus assumes a perfectly elastic demand curve for the output, as well as a perfectly elastic supply of any variable inputs that may be used.

The assumptions of additivity and proportionality together define linearity in the activities, thereby giving rise to the name 'linear programming'. They also define linear isoquant sections in resource use between pairs of activities. In other words, the firms aggregate production function relate the value of the linear objective function and the fixed resources with constant returns to scale.

An important property of production functions exhibiting constant returns to scale is known as Eulers Theorem which states that if each factor is valued at its marginal product (i.e. at its marginal cost), then the sum of the factors multiplied by their marginal product (or marginal cost) is equal to the total output: i.e.  $Y = \sum E x_i \cdot (dY/dx_i)$ .

This implies that in the optimum solution of a LP model, the sum of each resource available multiplied by its marginal value product exactly exhausts the value of the objective function.

As mentioned earlier, the linearity assumptions that are implicit to a LP model may however introduce some degree of inexactness in the model because non-linear production functions or complementarity / substitutability in resource use cannot be directly modeled. To reduce such inexactness, non-linear activities (ex. the crop yield curve) and constraints can be 'linearized' through separable programming techniques which involves approximating the non-linear function into a series of linear segments which are defined over intervals. A series of linear segments can then be summed to describe a non-linear function through the use of convex-combination constraints.

#### 2.4 Characteristics of Intertemporal (Dynamic) Linear Programming Models

In Dynamic (intertemporal) Linear Programming, the following kinds of linkages have to be considered:

1. The firm's income in a given year will affect savings and borrowings, and therefore may affect possibilities for investments in future years.
2. Investments affect the capacity for production in later years.
3. There exist biological intertemporal linkages, such as the yield curve over time in tree crops and other perennials, and reproduction and growth rates for livestock.

Also, the manager may reasonably be expected to have a subjective discount rate, and his objective function will include, among other variables, some transformation of his discounted income stream.

The reader should note that in using Linear Programming techniques, we are assuming that the behaviour of plantation companies to be approximately perfectly competitive in product as well as factor markets. In other words, the existence of a many small producers who are therefore price takers (the demand conditions facing such firms being perfectly elastic) is assumed. In factor markets, the larger the number of buyers, the less can any one firm influence the price it pays for a factor by changing the quantity it uses. Hence, plantation companies may also be assumed to be 'near-perfect' competitors in factor markets.

The existence of imperfectly competitive elements in agricultural commodity markets could provide many instances where Quadratic Programming techniques (where the Objective Function is quadratic) would be more appropriate than the Linear Programming approach.

### 2.5 Risk Considerations

One of the assumptions implicit to linear programming, is that all data (resource supplies, input-output coefficients and yield, price and costs) are known with certainty. Obviously this is a rather big assumption to make, especially in an intertemporal setting where the values of these variables in the distant future would have to be predicted.

In practice, the error terms associated with some types of agricultural production data merit special consideration due to the degree of variability (risk) associated with the variable.

In Risk Programming, it is assumed that the planter / decision maker has an utility function that exhibits a trade-off between risk and income. An E-V indifference system (Expected income vs Variance in income) specifying that he will be 'better-off' the higher his expected income and the lower his income variability would thus help the manager in making a decision.

A commonly cited weakness of this approach is that the decision maker does not usually mind if his income variance is positive (i.e. above the mean expected income), whereas the approach assumes all variances (positive and negative) is undesirable.

In any case, the Risk Programming problem is mathematically defined as follows:

$$\max Z = E.(PY) - \phi V.(PY)$$

such that

$$E.(PY) \geq 0$$

where,  $\phi$  = risk aversion parameter.  
 P = Price of Commodity  
 Y = Yield  
 E = Expected (Mean) Income  
 V = Variance in Income

An alternative procedure of appreciating the amount of risk involved without having to make major modifications to a deterministic LP model is to conduct sensitivity analyses where the degree of changes in parameter values to the optimal solution is accessed. This technique would be more appropriate for use with an intertemporal LP model as the variances and mean values of some parameters in future years (such as commodity prices) cannot be determined *a priori*.

## 2.6 Literature Review

Since the objective of this study is to develop a linear programming decision making framework by which to derive optimal land-use plans for perennial crops, it would be beneficial to briefly review some of the various intertemporal linear programming models that have been used in the past to solve similar management problems.

Hazell and Norton (1986) provide a good coverage of both traditional and innovating techniques for approaching questions of interest to decision makers at the farm (and sector) level.

Crop production models that are intertemporal in nature have been developed by Rae (1968, 1970) to illustrate this model's applicability to farm planning with respect to the optimization of annual and perennial crop mixes. His model determines the optimal growth path for a farm given an initial stock of capital and investment levels. This was achieved through the incorporation into a basic production model, of annual capital constraints that are specified in such a manner so as to simulate annual cash flows. That is, capital can be supplied in each year (for the purchase of production inputs) from credit, or from savings carried over from the previous year; all revenues (from crop sales) are taxed on a progressive basis to obtain the after-tax cash balance from which consumption requirements are met. Vandeputte and Baker (1971) provide detailed specification for the allocation of income among taxes, consumption and savings while Boehlje and White (1969) define the basic components of a time based production investment decision model of farm firm growth (applying it to a hypothetical hog-corn farm).

Intertemporal investment models dealing purely with perennial crops have also been developed. Willis and Hanlon's (1976) model selects an 'optimum' mix of apple varieties for planting over time, while those of Ecker (1974) and Kwong (1975) select the 'optimum' time of replacing apple and rubber trees respectively by incorporating annual replanting activities in their model.

A model by Abalu (1973, 1975), optimizes perennial crop mixes and crop combinations with respect to the planting of bananas, coffee, cocoa, oil palm, cocoa-bananas, oil palm-cocoa and oil palm-coffee. He developed two planting horizon model variants - one where plantings are allowed in only the initial year and another where plantings are permitted over several years, and notes that the differences in the two optimal planting plans obtained are minor.

The land allocation model developed here is similar to Abalu's in that it determines the optimal (profit maximizing) perennial crop mix and time of planting on soils having different characteristics and therefore production capabilities. In the model formulated here however, plantings are only permitted within a pre-specified land allocation period. Being a land allocation model (not a growth model), it does not optimize the time of replacing the perennial crops considered (rubber, oil palm and cocoa) assuming that replanting occurs at the crops respective optimal rotation ages.

Chapter 3

THEORETICAL FRAMEWORK

3.1 Features of Linear Programming Models

3.1.1 The Static LP Model

The basic Static LP Model consists of 3 components:

- an Objective Function
- various Activity Functions
- various Constraint Functions

This Static LP Model can be mathematically represented as:

$$\begin{aligned} \text{Max TGM} &= \text{GM}_1 \cdot x_1 + \text{GM}_2 \cdot x_2 \\ \text{s.t. Output: } &a \cdot x_1 + B \cdot x_2 \geq 0 \\ \text{Input: } &a \cdot x_1 + B \cdot x_2 \leq 0 \\ \text{Land: } &x_1 + x_2 \leq \text{Area} \end{aligned}$$

where, TGM = Total Gross Margin (or Profit, n).  
 GM<sub>n</sub> = a vector of Gross Margin obtained from activity unit x<sub>n</sub>, i.e. per Ha of Crop n.  
 x<sub>n</sub> = a vector of cropping activity levels.  
 (Note: x<sub>n</sub> ≥ 0)

3.1.2 The Intertemporal LP Model

In an Intertemporal LP Model, where the time factor has to be incorporated, there are some distinguishing features. This arises because the amount of land, labour and capital resources available and / required may vary in different time periods, particularly where non-annual cropping systems are concerned.

Such distinguishing features of the intertemporal LP model are:

1. Activity and Constraint functions are 'dated' to specific time units.
2. Income and Expense Flows (i.e. Cash Flows) from one time period (time unit) to the subsequent periods has to be defined. As such, financial transfer functions have also to be modeled.
3. Activities and Constraints that are dated to a particular time period may have to be linked with not only each other within the same time period, but also with activities and constraints in other time periods.

Thus the main distinguishing feature of the intertemporal model as opposed to the static model is that of the transfer of resources and monetary capital between the various time periods (Olsson, 1971).

### 3.2 Structure of the Perennial Crop Land Allocation Model

In approaching an optimal land allocation solution for perennial crops, dynamic (i.e. intertemporal) linear programming is preferable as an analytical tool to derive normative crop mixes (through time).

The basic structure of such a model should allow for multiple product (cropping) combinations and multiple resource restrictions (with respect to labour, capital and land) within each year, as dictated by agronomic, risk and price considerations.

It should aim to maximize the present value of net annual profits through time (and perhaps, also the simultaneous minimization of risk). A 25 year period should ideally be modeled because this is the maximum productive lifetime of all the three perennial crops considered in this study. Alternatively, a finite number of years sufficient for a realistic planting programme to be completed can be modeled, with all ongoing cash income or expenses from future years represented in the final year terminal value row as asset values.

However, before constructing an intertemporal model, consideration has to be given to the following problems that are normally encountered in a study of this nature:

The uncertainty problem which arises from the fact that factors such as prices (both input and output), climate (which could affect yields), etc. cannot be predicted with any degree of certainty.

The capital formation problem which lies in the fact that a choice has to be made (subjectively) between consumption and saving for (re)investment in any time period (Boussard, 1971). Obviously, the more the firm saves (i.e. the less it consumes), the more it has to invest by increasing its capital resources from the previous year, thus leading to a more flexible capital resource restraint being incorporated into the model in any year. The Marginal Propensity to Consume, MPC of the decision maker would reflect this trade-off between consumption and saving / investing.

The value of time problem which refers to the perceived cost that the decision maker faces in measuring monetary benefits from future time periods in today's terms. The plantation manager therefore has to choose an 'appropriate' interest (discount) rate that is to be used in deriving the present value of future streams of net income.

Normatively speaking, the 'appropriate' discount rate would be the market rate of interest if it truly reflects the marginal productivity of investment and time preference. Thus, in an utopic financial market, the discount rate would be the same as the borrowing and savings rate.

It should be realized that the discount rate has a very critical bearing in making land-use decisions where the various perennial crops show different periods of immaturity. Obviously, if the opportunity cost of time is high, we would prefer to get our income sooner rather than later. This would in turn have us favour perennial crops with shorter immaturity periods.

To access the effects of subjective-cum-exogenous data used in the model arising out of price uncertainty, consumption and investment trade-off preferences of the decision maker, and the value of time as it relates to future income, model calculations should ideally be repeated for different values of these variables to judge the stability of the profit maximizing plan i.e. a sensitivity analysis should be conducted.

### 3.2.1 The Planning Horizon

The inclusion of the 'time' factor in the basic LP model leads us to consider the following (very relevant) question:

*"For over how many time periods should the profit maximizing objective function be maximized?"*

Obviously, a manager who is say, 5 years away from retirement, will only plan to maximize his utility over the next 5 years. This is in accordance with Olsson's (1972) suggestion that the planning horizon should not be further in time than is of interest to the decision maker.

As such, in a study dealing with perennial crops, the planning horizon should be restricted up to either the longest Optimum Rotation Age of all the perennial crops considered, or up to the point in time that is of interest to the decision maker, whichever is shorter.

If we are to assume that the working lifetime of the decision maker exceeds that of the rotation ages of the perennial crops used in this study (about 25 years), then the planning horizon will be the rotation age i.e. 25 years. This assumption is especially realistic if the decision maker over the entire planning horizon is not any one individual manager, but a series of successive managers, as is found in the case where plantations are owned by companies with many shareholders.

In contrast, individual farmers are not as inclined to plant perennial crops (particularly if the crop's immaturity period is long). And they will almost certainly not be interested in growing forest species. His time horizon is shorter and therefore his preference leans more towards cultivating annual crops, or shorter term perennial crops.

Since capital budgeting involves the planning of cash allocations over a series of time periods, it is useful to know (prior to modeling) how far into the future such capital budgeting should be carried. As the budgeting is carried further into the future, the less will each additional time period affect the desirable investment policy in the first time period. (How much less would of course depend on the discount rate chosen by the decision maker as reflecting his rate of time preference).

Since *a priori*, it is not possible to know how the length of the planning horizon affects investment decisions in the first time period, Rae (1970) suggests that the time period considered should be continually extended until the investment decision in the first time period becomes insensitive to further extensions of the planning horizon. He points out that by examining several planning horizons, the sensitivity of the first time periods policy to changes in the length of the planning horizon, and the most profitable policy for the first time period, will be ascertained.

But we have thus far neglected to allow for adjustment in investment directions from within the planning horizon to unexpected changes in product prices, factor prices, new production technologies, non-eradlicable pest infestations etc.

Therefore, it might be more realistic when it comes to making cropping investment decisions that are based heavily on expectations of commodity product and factor prices in the distant future, to partition the long run planning horizon (taken in this study to be the rotation age i.e. 25 years) into a series of sequential 'decision making' horizons. This would require the formulation of a model with an initial inventory of cash and land assets and simulating a finite number of years long enough to cover the planting programme (say 3 years), the inventory at the end of the explicit simulation being valued to reflect expected future returns.

Such a finite short run 'decision making' or land allocation horizon need only be long enough to implement investment decisions based on information (product prices, input costs etc) that is already available or known with a high degree of certainty; and / or on the amount of investment capital currently available.

This approach has the advantage of providing the decision maker with some flexibility to change investment directions in a subsequent short run 'decision making' horizons should future commodity price expectations or the amount of investment capital available change, both in the subsequent short run 'decision making' horizon as well as in the remaining part of the encompassing long run (25 year) planning horizon.

As in this study, the optimum rotation age is taken as the long run planning horizon, a review of the theory used in determining the optimal rotation age of a perennial crop would be appropriate at this time.

Then, in the short run 'investment decision making' 3 year model that is actually formulated in this study, the discounted long run expected returns from year 4 up to the calculated rotation age (determined to be 25 years) can be imputed as the Terminal Asset Value in the third and final year of the model.

### 3.2.2 The Optimal Perennial Crop Replacement Time

The optimal rotation age (i.e. the Replacement time) for a perennial crop is when the annual net revenue (marginal value product) from the current crop becomes equal to the amortized present value (annuity value) of the net revenue from the following crop.

#### Determination of the Optimum Rotation Age

The yield, Yld of a perennial crop in any year is a function of Age, t, where time is treated as an input in the production process:

$$Yld, Y = f'(t). \quad \text{Annual Yield Function}$$

The cumulative yield at age t, would be the summation (i.e. the integral) of this annual yield function:

$$\Sigma_t Yld = \int f'(t) = f(t) \quad \text{Cumulative Yield Function}$$

Therefore, the Accumulated Revenue, Rev in any year at age, t is represented by the integral or summation of Price, P times the annual yield:  $\Sigma P.Yld = \int P.f'(t)$ ; and the Accumulated Annual Variable Costs is given by  $\int C'(t)$ .

Cumulative Profits,  $\Sigma_t PR$  is the present value of all annual Revenue obtainable by clearing at age, t minus the present value of Costs incurred upto age, t :

$$\Sigma_t PR = \Sigma_t [Rev/(1+r)^t] - \Sigma_t [Costs/(1+r)^t]$$

Using continuous discounting, this can be written as:

$$= P.f(t).e^{-rt} - C(t).e^{-rt}$$

where r = discount rate.

Thus, Maximum Profits, PRmax can be determined by taking the first derivative of the above profit function and equating it to zero as shown:

$$PR_{max} = [P.f'(t).e^{-rt} + -r.e^{-rt}.P.f(t)] - [C'(t).e^{-rt} + r.e^{-rt}.C(t)] = 0$$

$$\text{or } P.f'(t) - C'(t) = r.[P.f(t) - C(t)] \quad \text{Eqn 1}$$

**Note:**

-  $f'(t)$  is synonymous with Annual Yield Changes, i.e. the Marginal Physical Product. Thus  $P.f'(t) - dC'(t)$  is the net Marginal Revenue, obtainable from keeping a perennial crop standing one more year.

-  $r.[P.f(t) - C(t)]$  represents the revenues foregone by delaying crop rotation by one year. Thus this is the Marginal Cost of keeping the perennial crop standing one more year.

However, the above condition for determining the profit maximizing rotation age (Eqn 1) does not take into account the opportunity cost of subsequent use of the land after the current stand of trees is cleared. Thus the marginal cost as defined above underestimates the true marginal cost if the land has some use after felling. For example, the land could be planted with the same or a different crop.

If we assume that the land is going to be replanted with the same species after every rotation, then the marginal cost has to be discounted to infinity so as to also reflect the present value of the opportunity cost of all future stands that the land can sustain :

$$r.[P.f(t) - C(t)] / (1-e^{-rt})$$

As such Eqn 1 would then be modified to Eqn 2:

$$P.f'(t) - C'(t) = r.[P.f(t) - C(t)] / (1-e^{-rt}) \quad \text{Eqn 2}$$

This condition for deriving the optimum (profit maximizing) rotation age is known as the Faustmann formula. Given information on crop yields at various ages,  $f'(t)$ , and the rate of time preference,  $r$ , this equation can be solved for  $t$  to give the optimal rotation age.

The optimum time to replace the three perennial crops considered in this study when the discount rate,  $r$  is 5 %, (assuming of course that yield, price and cost predictions hold good in future years) are:

Rubber	:	25	years
Oil Palm	:	23 - 27	years
Cocoa	:	20 - 30	years

These rotation ages generally appear to be consistent with those observed in practice. The range of rotation ages observed are due mainly to differences in yields (i.e. the production function) under various agro-climatic regimes.

### 3.2.3 The Objective Function

In modeling the Objective Function, the plantation manager's goal(s) has first to be defined in order of priorities. Very seldom is it the manager's sole objective to maximize profit, although this is usually his primary goal. Often, he also wishes to simultaneously minimize risk (mainly arising from yield and/or price fluctuations) at a particular income level; or to derive a less variable year to year income. In other words, a rational manager would want to make as much money with as little risk as possible, and preferably, with the minimum of effort (labour and capital requirement) as well.

The fact that firms generally pursue several (often conflicting) objectives in addition to that of profit maximization, should therefore be incorporated into the Objective Function of the intertemporal model. The approach adopted in this study (and in Rae, 1970), assumes that the decision makers utility may be expressed as a linear combination of the appropriately weighed objectives, and may also be lexicographic in that some other objectives must also be satisfied in all solutions.

That is ...

$$U = f( a_1 \text{ TGM}, a_2 \text{ NW} ; C )$$

where,

- U = Utility
- TGM = Tot. Gross Margin (or Profit)
- NW = Net Worth (or Asset Value)
- C = a separate annual Consumption objective, the achievement of which is compulsory (and which is therefore modeled as a constraint).
- a<sub>1</sub>, a<sub>2</sub> = weights applied to the TGM and NW objectives.

In this lexicographic formulation, there exists no satisfactory trade-off between TGM, NW and C, i.e. the firm is prepared to sacrifice all TGM and NW in order to meet the C objectives.

Unless specific values can be given to the weights prior to computation, the weighing problem could be resolved by determining many 'optimal' solutions, each for a different combination of 'a' values. Thus an 'efficient set' of solutions will be derived, allowing a objective choice of the utility maximizing solution to be made.

The choice of weights could, for example, depend on the state of the economy. A nation which has a high inflation / low interest rate would tend to have decision-makers favour asset accumulation over cash accumulation. In a similar vein, if a nation's exchange rate is depreciating or likely to be devalued, the firm (particularly the multi-national firm) would emphasize asset building over cash income. Such macroeconomic conditions however tend to lead to reduced mobility of capital between investments / nations.

For the purposes of this study however, where the objective is specified as the maximization of final year cash balance (i.e. TGM) and asset values (i.e. NW), the weights used to discount the objective function values at the conclusion of the final year (Year 3) into present value terms were given equal priority.

Two additional objectives were also specified as constraints:-

- a Consumption constraint to meet fixed and variable consumption requirements (as dictated by the decision makers marginal propensity to consume).
- a Borrowing Limit constraint to limit indebtedness and to allow the manager to operate flexibly.

### 3.2.4 The Activity Columns

The main activities considered (on an annual basis) in a land allocation model are categorized as follows:

**Cropping** - The cultivation of three perennial crops on twelve soil types are considered in this study. As such, thirty six activities are required to allow each crop-soil production relationship to be modeled, particularly as their yield profiles are quite different. All the crops (Rubber, Oil Palm and Cocoa) generally follow 25 year rotations and as such the model should also reflect cropping returns over this whole period (either implicitly or explicitly).

**Crop Selling** - These activities should allow the cumulative production from all cropping activities to be sold to contribute to the pretax Closing Cash Balance account.

**Hire Labour** - The three crops require different levels of labour intensities with respect to tapping / harvesting, fertilizing, pest and disease control etc. at various stages of crop maturity. Thus this activity should allow for the hiring of labour according to the labour requirement of the cropping mix in the optimum plan at a particular time.

**Buy Capital/Fertilizer** - Similarly, all three crops require different levels of capital intensity with respect to capital inputs used for tapping / harvesting, fertilizing, weeding, pest and disease control etc. Thus this activity should allow for the usage of capital to purchase the required inputs for the production process (such as herbicides / pesticides, fertilizer etc) at a particular time.

**Borrowing and Saving** - These activities should permit borrowing on credit (when accumulated cash-flows are negative) as well as for lending / saving with interest (when accumulated cash-flows are positive).

**Financing (including Taxation and Consumption)** A tax-deduction and tax-loss transfer activity is required to allow annual tax deductible expenses (in the Tax Deduction / Loss account) to be subtracted from the gross annual income (the Taxable Income account). The balance can then be taxed through tax-transfer activities and the remaining amount be transferred to the start of the following year as a cash flow (through the after-tax Closing Cash Balance account) after fixed and variable consumption expenditures are removed (and after borrowings are repaid and savings withdrawn).

Taxation transfer activities are therefore required to model tax-deductible expenditure (upto some specified limit), and to model cash that is taxed on a progressive basis for transfer to the after tax Closing Cash Balance account.

**Terminal Value (Asset Value plus Accumulated Cash Balance)** - The only purpose of this activity is to transfer the accumulated value of assets in the final year (reflecting the income generating capacity of planted areas in future years not implicitly accounted for in the model), together or separate from the accumulated final year cash balance (from the final year Closing Cash Balance account), into the objective function which is maximized.

**3.2.5 The Resource Constraints & Reconciliation Rows**

The various resource constraints and reconciliation rows that are normally encountered in any period when arriving at a Optimum Land-Use Plan are:

**Crop Output row** - These rows allow the collection of the cumulative yield from all the various cropping activities for sale via the crop selling activities.

**Crop Input row** - These rows allow for the purchase/hiring of all inputs (fertilizer, labour, capital) required by the various cropping activities for sale via the fertilizer purchasing, labour hiring and capital purchase activities.

**Land constraint** - As 'Land' is a non-uniform entirety (i.e. there are different soil types, having different plant nutrient contents, water holding capacities, topsoil depth, slopes, etc.), constraints are required to make each soil type available for allocation to the various crops considered.

*Note: In this study, soil types are classified (by slope and textural characteristics) according to their agricultural productive capacity with respect to the various crops considered. The soil nutritional status was not considered in the actual classification (to limit the size of the model). However, if the soil nutrient status is known, the fertilizer input coefficients can be adjusted accordingly for each crop-soil type cropping activity.*

**Climate** - The Climatic resource refers to such factors as Humidity, Rainfall (amount in a year, as well as distribution within a year), the amount and intensity of Sunshine, Temperature and Wind speed. Since the study considers tropical crops, seasonal affects on crop production are mainly observed in rainfall, humidity, and temperature.

**Note:** *Climatic constraints were not included in this study as its inclusion would increase the computational requirements significantly (since many climatic variables have to be considered). A more efficient way to get around this (i.e. without requiring more computational power) would be to increase the number of cropping activities to model production possibilities for different climatic conditions in addition to different soil types. But since this study is concerned with crop production in a single location, the modeling of crop-soil-climate production activities becomes redundant. Instead, in the land allocation problem addressed by this study, only crop-soil activities were modeled.*

**Labour** - The Labour requirements for the cultivation of each of these perennials are modeled through these constraints.

**Capital** - Similarly, the Capital input requirement (pesticides, fertilizers etc.) for each cropping activity are modeled through these constraints.

**Financial** - The following financial constraints are incorporated into the model to simulate year-to-year after tax cash flows:

- an Opening Cash Balance constraint to limit total expenditure to no more than cash available at the start of a year plus borrowings and less saving deposits. (In the first year, the cash available at the start of the year is specified as the Start-up capital, while in all subsequent years, the cash available at the start of the year is equivalent to the cash collected at the end of the previous year as specified in the Closing Cash Balance row of the previous year i.e. from after-tax income less expenses, repaid borrowings, withdrawn savings and consumption removals).
- a Taxable Income constraint that allocates all pretax income (from crop sales and interest received on savings deposits) to the various income tax brackets (including tax deductions) in a manner that satisfies the tax limit constraints.
- Tax Limit constraints to specify the allocable limits of pretax income into the various income tax brackets.
- a Tax Deduction / Loss constraint that allocates all costs (arising from the purchase of crop inputs and interest on borrowings) to either tax-deductions or tax-losses (the latter for consideration as a tax-deductions in the following year).
- an Expenses constraint that collects all expenses categorized under tax-deductions and tax losses into Total Costs.

- a Closing Cash Balance constraint which sums all after-tax cash receipts (including tax-deductions), and from which all tax deductible expenses are subtracted, borrowings repaid, savings withdrawn, and consumption requirements met. The balance is then collected as a Cash Surplus (or Cash Deficit) for transfer into the Opening Cash Balance row of the following year.
- a Consumption constraint to remove fixed and variable consumption requirements from the Cash Balance account.
- a Borrowing Limit constraint that restricts borrowings to some prespecified limit.

**Terminal Value (Asset Value plus Cash Balance)** - The Terminal Value constraint appears in the final year of the model and is used to determine final asset values at the end of the planning horizon after adjustment for the final year cash surplus / deficit i.e. the final year accumulated cash balance.

*It should be noted that in a model formulation such as the above, commodity prices are assumed to be derived from a perfectly competitive market (i.e. where the demand curve is perfectly elastic).*

*A more rigorous approach would include the insertion of empirically derived supply and demand functions of all trade partners (after adjustment for transportation costs, tariffs, quotas etc.) in the restraints subject to total supply being equal to total demand of all countries, to obtain the market clearing price. This price value would more accurately reflect market conditions and as such would be more suitable for use in this framework. Determining prices endogenously in this manner would involve more complex modeling, involving the specification of Supply and Demand functions through the use of convex-combination constraints. in a spatial equilibrium framework.*

After discussing the agro-climatic factors involved in the cultivation of rubber, oil palm and cocoa in Chapter 4; and after reviewing the market situation for the crop products and inputs in Chapter 5, the land allocation model is formulated in Chapter 6.

## Chapter 4

### CROP PRODUCTION

This chapter discusses the agro-climatic production factors that are considered important in the cultivation of Rubber, Oil Palm and Cocoa.

Since the land allocation model that is developed in this study allocates land only on the basis of soil type, the other agro-climatic factors discussed here (such as rainfall, humidity, the prevalence of pests and diseases etc.) should also be considered prior to deciding on the cropping activities that should be included in the model when applied to a particular geographical region or locality. The appropriate input-output coefficient with respect to yields obtainable and inputs required (such as labour capital and fertilizer) can then be derived for specification of the cropping activities when formulating the applied model.

#### 4.1 AGRO-CLIMATIC FACTORS IN CROP PRODUCTION

##### 4.1.1 Climate

The climatic factors that influence the performance of perennial crops are presented in Table 4.1.

The optimum climatic features for the various perennial crops are:

##### Rubber

Rainfall of 1000 - 2500 mm annually and preferably with a distinct dry period / season. (If annual rainfall is greater than 2200 mm and more evenly distributed, there is a greater likelihood of fungal disease infestations such as white and red root disease (*Lignus* spp.), leaf diseases (*Phytophthora* spp.) and panel diseases (*Phytophthora* spp.).

Mean max temperature of 29°C - 33°C; and mean min temperature of 18°C - 24°C.

Constant sunshine amounting to at least 5 hours per day in all months of the year and rising to 7 hours per day in some months.

The above climatic requirements allow for Rubber to be grown in diverse geographical locations. Rubber plantations are found anywhere from the equator to as far north as southern China and Bangladesh (about latitude 30° N/S).

See Fig. 4.1 - Climatic Factors influencing the cultivation of Rubber in Peninsula Malaysia.

Table 4.1.

## CLIMATIC FACTORS IN THE PERFORMANCE OF PERENNIAL LOWLAND CROPS IN PENINSULAR MALAYSIA

Crop	Dry season (months)	Surplus rainfall	Wind gusts	Sunshine (optimum)	Other factors	Max. elev. (m)
Rubber	- over 2	0	--	+	-- a.m. rf.	300
Oil Palm	- over 1; -- over 2	-	0	++ (5 hrs/day)	- irregular rf. + small diurn. temp. range	300
Cocoa	+ up to 1; -- over 2	-	-	-- (shading)	-- high R.H.	300
Coconut	- over 2	0	-	+(4 hrs/day)	- lightning + small diurn. temp. range.	900
Cassava	0 (-)	--	-	0		1200+
Coffee	+ up to 2	0	-	0		600 (Lib.) 1400 (Rob.)
Sugarcane	++	-	-	++	+ large diurn. temp. range	1450
Cashew	+ up to 4	0	-	0		700
Pineapple	0 (-)	--	0	+		1600
Grasses	-	0	0	0	- high temp. and R.H.	
Mango	+ up to 2½	-	-	++		1500
Banana	--	--	--	+		1500
Citrus	+ up to 2	-	-	+		1800
Papaya	-	--	-	+	+ large diurn. temp. range	900
Durian	+	0	-	+	+ large diurn. temp. range.	500
Pepper	--	0	0	0		300

-- : disadvantage    + : advantage    0 : no clear effect    -, + : minor effect    --, ++ : major effect.

Source : MARDI

### Oil Palm

Rainfall of  $\geq 2000$  mm annually, distributed evenly; i.e. a non-seasonal climate is preferred. (If rainfall is less evenly distributed, a higher rainfall would go some way in compensating for reduced yields that would have otherwise occurred where a dry period / season exists).

Mean max temperature of  $29^{\circ}\text{C} - 33^{\circ}\text{C}$ ; and mean min temperature of  $22^{\circ}\text{C} - 24^{\circ}\text{C}$ .

Constant sunshine amounting to at least 5 hours per day in all months of the year and rising to 7 hours per day in some months.

The above non-seasonal climatic requirements allow for Oil Palm to be grown only in equatorial regions. Thus Oil Palm plantations are normally found between latitudes  $0 - 4^{\circ}$  N/S.

See Fig. 4.2 - Climatic Factors influencing the cultivation of Oil Palm in Peninsula Malaysia.

### Cocoa

Rainfall of 1250 - 2800 mm annually, distributed somewhat evenly. If rainfall is greater than 2500 mm and very evenly distributed, fungal infestations are more likely and may lead to significant crop losses. Black Pod (*Phytophthora palmivora*) and Vascular Streak Dieback (*Oncobasidium theobromae*) are common to S.E. Asian cocoa plantations.

Mean max temperature of  $28^{\circ}\text{C} - 32^{\circ}\text{C}$ ; and mean min temperature of  $18^{\circ}\text{C} - 21^{\circ}\text{C}$ . The cocoa plant is naturally more suited to regions with a max temperature less than  $28^{\circ}\text{C}$ . However, if proper shade management is effected, the species can yield reasonably well even where the max temperature reaches  $32^{\circ}\text{C}$ .

Constant sunshine amounting to at least 5 hours per day in all months of the year and rising to 7 hours per day in some months. In the tropics, young plantings should however be shaded until a good canopy develops (at about four years of age) as this allows for greater photosynthetic efficiency to be achieved under a lower microclimate temperature regime. Furthermore, insect damage to this susceptible species is reduced. (The *Helopeltis* insect is a serious cocoa pest in Malaysia).

The above climatic requirements allow for Cocoa to be grown in somewhat more diverse geographical locations than Oil Palm (but less widespread as Rubber). Cocoa plantations are found anywhere from the equator to central America (about latitude  $25^{\circ}$  N/S).

#### 4.1.2 Soils

The Physiography, Rock Types and Soil Types that are found in Malaysia are tabled in Appendix 1.

Fig. 4.1

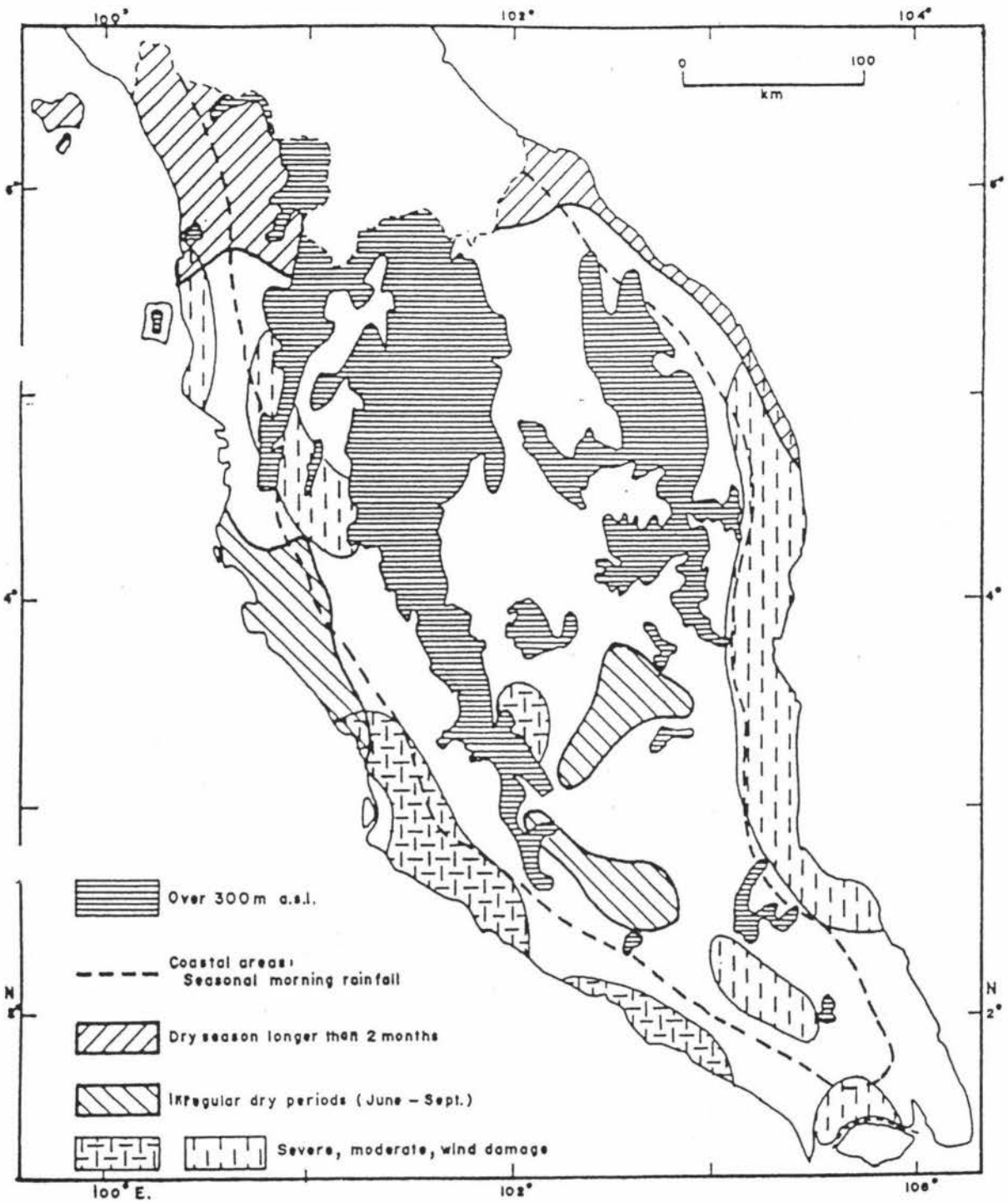


Figure — Climatic factors influencing the cultivation of rubber.

Source : MARDI

Fig. 4.2

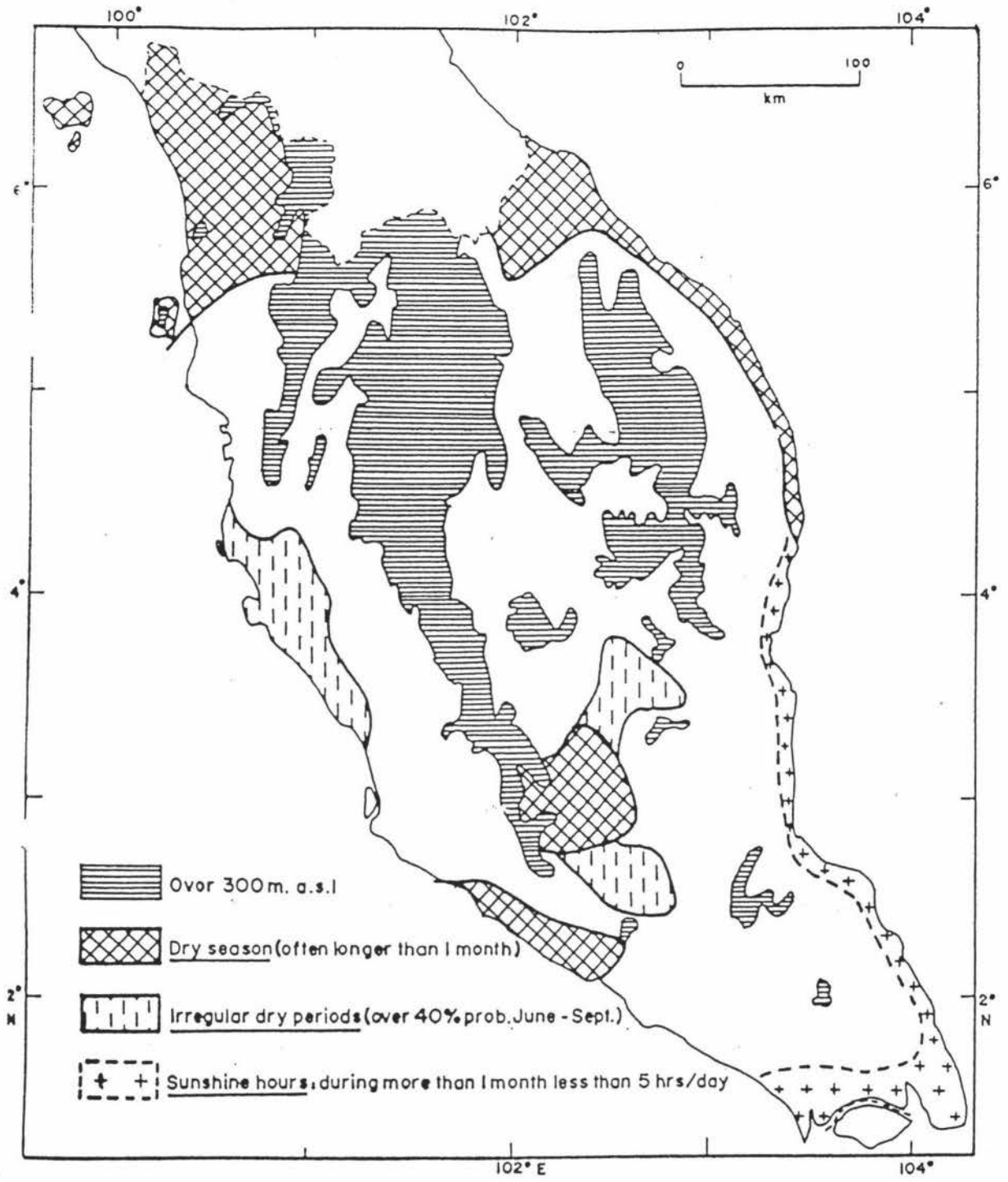


Figure — Climatic factors influencing the cultivation of oil palm.

Source : MARDI

### 4.1.3 Crops

#### a. Rubber

The Rubber tree grows well in the humid tropics. It however does not do well in very high rainfall or low-lying areas subject to water logging, as this is conducive to the spread of fungal diseases to which the tree is very susceptible. It is mainly for this reason that Rubber is usually preferable for planting on hilltops and on sandy soils where excess water quickly drains away. The deep tap root of the rubber tree also has the advantage of controlling soil erosion.

Due to the Rubber trees susceptibility to root disease of a fungal nature (white and red root disease) under high rainfall / humidity and clayey soil conditions, the replanting of rubber under such micro-climatic conditions is usually avoided, i.e. the Rubber field is rotated with some other species.

The yield profile of Rubber under various agro-climatic conditions existing and tapping systems being practiced in Malaysia and Indonesia are graphed in Appendix 2. The labour and capital (including fertilizer) inputs required in Rubber cultivation are tabled in Appendix 3.

#### b. Oil Palm

The Oil Palm, in contrast to Rubber which has a deep tap root system, has a shallow fibrous root system and so is better able to survive water logged conditions. In fact, its yields are higher in high rainfall areas, particularly where the rainfall is evenly distributed throughout the year. Because of this beneficial effect of water on palm yields, oil palm plantings are considered more suitable for low-lying areas where the soil water content is higher than on hilltops. Oil Palm plantings on sandy soils are usually avoided as these soils have a high water infiltration rate and leads to excessive leaching of fertilizers. Leaching losses of soluble fertilizers is a particularly important factor as the oil palm requires massive fertilizer inputs. Also, because of the high fertilizer dosages that are required by the oil palm, it is significantly more cost effective to grow palms on nutrient rich soils (especially if such soils have a high water holding capacity as well).

The yield profile of Oil Palm under various agro-climatic conditions existing in Malaysia and Indonesia are graphed in Appendix 2. The labour and capital (including fertilizer) inputs required in Oil Palm cultivation are tabled in Appendix 3.

c. Cocoa

The Cocoa tree is intermediate in its water requirements between Rubber and Oil Palm. Thus this crop is generally planted in level to sloping terrain.

As this crop is not able to tolerate very high temperatures, it is usually planted in shaded areas such as behind hills and in valleys. It is also preferable to plant this species in a climatic region where there is a relatively high amount of cloud cover in a year. This preference of the cocoa plant for shade is particularly important during the immaturity period i.e. upto age five. It is for this reason that 'shade' trees are normally planted between the planting rows a few years prior to planting. The presence of shade trees also has the advantage of reducing insect damage, especially in young plantings where such damage is potentially more serious.

The species also produces pods that are less acidic (and so commanding a premium on the market) if grown on soils that are less acidic. As most soils of the tropics come under the classification of Oxisols and Ultisols which are highly leached and therefore acidic, the application of a significant quantity of fertilizer lime (calcium carbonate) is often necessary. However, if Cocoa is grown on the relatively 'newer' and more alkaline volcanic soils which are classified under Entisols, liming costs are much less. Such 'newer' soils are sometimes encountered in Indonesia.

The yield profile of Cocoa under various agro-climatic conditions existing in Malaysia and Indonesia are graphed in Appendix 2. The labour and capital (including fertilizer) inputs required in Cocoa cultivation are tabled in Appendix 3.

Chapter 5

MARKETS

A review of the current and expected world commodity market situation for the perennial crop products considered in this study, is examined in this section so as to provide a comprehensive overview when making investment decisions involving these three perennial crops. A review such as this would serve to indicate the possible supply and demand situations (and by extension, the price regimes) that can be expected during the long lifetime of these perennial crops.

In addition, a look at the effect of structural change in the economy on resource endowments in producing regions (Malaysia and Indonesia) is warranted so as to assess the comparative advantages existing in these regions with regard to meeting crop input requirements. This review of factor input markets would give the decision maker some idea on future labour and capital input costs in a cropping enterprise.

5.1 WORLD COMMODITY MARKET OUTLOOK

Rubber

The advent of synthetic rubber (synthetic isoprene as well as synthetic non-isoprene rubbers) has led to the creation of weakly separable markets which are determined largely by the characteristics of the final product for which rubber is an input in the manufacturing process.

Therefore, the Rubber market can generally be divided into 3 not very distinct sectors:

- Isoprene market.

Both synthetic and natural isoprene can be used to satisfy this market, and the extent of their use depends solely on their price competitiveness.

Thus far, natural isoprene has remained significantly more cheaper and thus has captured almost the whole of this market.

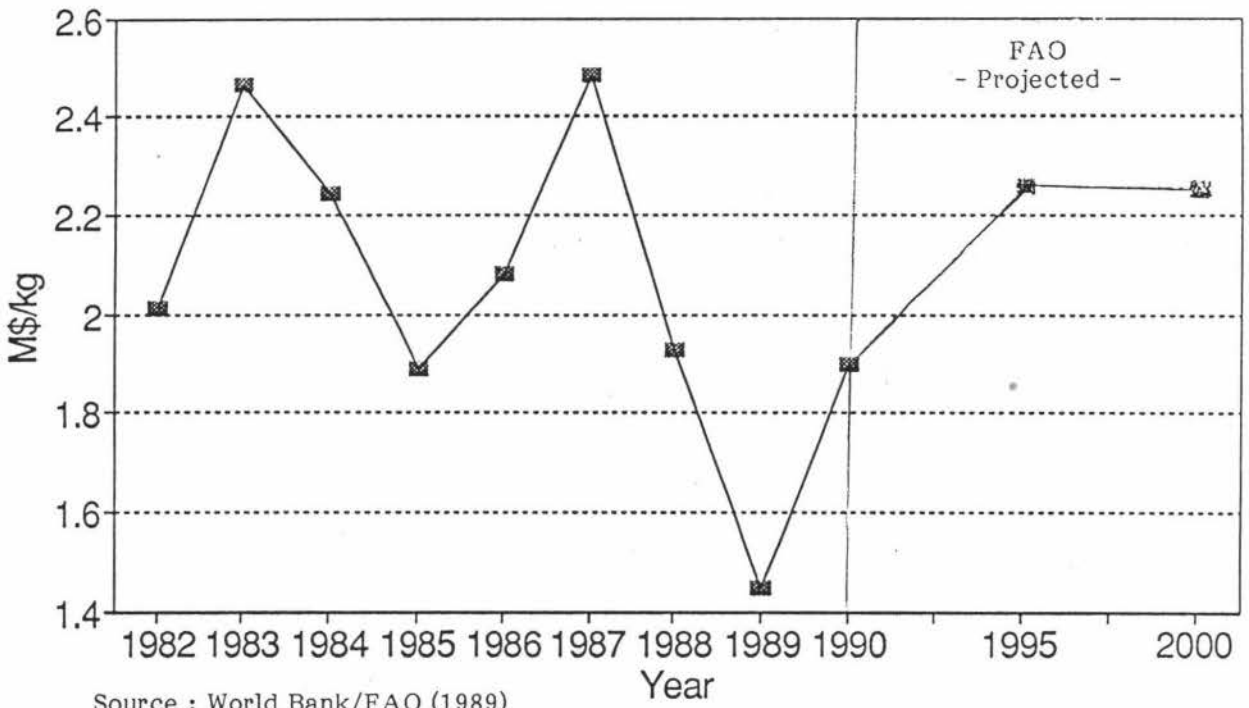
- Substitutable Isoprene - Non-isoprene market.

Both isoprene (natural and synthetic) and non-isoprene synthetics can be used to satisfy this market. The extent/proportion of their use depends largely on the desirable physical and chemical characteristics of the final end product and the relative prices of natural/synthetic isoprene versus synthetic non-isoprene rubber.

Fig. 5.1

# Rubber Prices

(M\$/kg dry rubber - RSS 1)



Source : World Bank/FAO (1989)

- Non-isoprene market.

Only synthetic non-isoprene rubbers can be used to satisfy this market for inputs into various manufacturing processes. Thus natural isoprene rubbers does not participate in this market.

The US, which produces no natural (isoprene) rubber, was the largest importer, taking about 769,000 tons / year in 1987. Japan was the second largest importer. Collectively, however, the EEC imports more natural rubber than does the US.

Malaysia, the largest natural rubber producer, accounted for about 35 % of the worlds output in 1987. Indonesia produced 20 % and Thailand 17 % (and catching up to Indonesia). China, India and Sri Lanka mainly account for the remaining world output.

Non-isoprene synthetic rubber production, which was about double natural isoprene rubber output in 1987, continued to accelerate at the end of 1988. The USSR was the largest synthetic rubber producer, followed by the US and Japan - together producing about 61 % of the worlds output in 1987. The US which outproduced the EEC, exported 15-20 % of its production, while the USSR consumed most of its output.

Natural (isoprenoid) rubber is primarily used in Radial tires, where more is required than in bias-ply tires. Since radials have steadily gained market share in the passenger car market (as well as in trucks and busses), the usage of natural isoprenoid rubber (which is cheaper than synthetic isoprene) has also increased. (Market share for radials rose from about 68 % of production in 1982 to almost 90 % in 1987 for passenger cars alone.)

World synthetic rubber production in 1988 was 2.655 million tons. Due to the softness of the US dollar, US exports of manufactured items is expected to rise, thus boosting demand for synthetic (non-isoprene) rubber.

It should be noted that the world production of natural rubber is dwarfed by a much larger output of oil-based synthetic rubber, which is a close substitute in many applications. Thus all natural rubber producers are essentially price takers in the international rubber markets. Currently (in 1989), the proportion of natural rubber in the world elastomer market stands at 33 - 35 %.

Oil Palm

Oils & Fats

The various oils and fats (esters), with their characteristic fatty acid - alcohol compositions, compete with each other to various extents in satisfying the input requirements of a multitude of end products.

International trade in the oils and fats market is of substantial and growing importance. Trade and production of each of the oils and fats are influenced by their own specific technical and economic characteristics as well as by relationships with other oils and fats.

The FAO (1987-1988) indicates that world output oils and fats in 1986 was 73.9 million tons (with exports of 24.8 million tons). Comparable figures for a decade earlier are 43.4 million tons (and 13.2 million tons exported).

In 1986, the value of oilseeds, oils and fats, and meals was US \$ 23.3 million (or 10.29 % of total world agricultural exports (excluding exports of forestry and fishery products). Exports of oils and fats alone accounted for 5 % of world agricultural exports in 1986.

Production and trade in oils and fats can be grouped into Vegetable and Animal oils/fats:

- Vegetable Oils
  - Annual Crops
    - Soybeans
    - Groundnut
    - Sunflower
    - Cottonseed
    - Rapeseed
    - and others ...
  - Perennial Crops
    - Oil Palm
    - Coconut
    - Olives

- Animal Fats
  - Cattle
  - Hogs
  - Fish

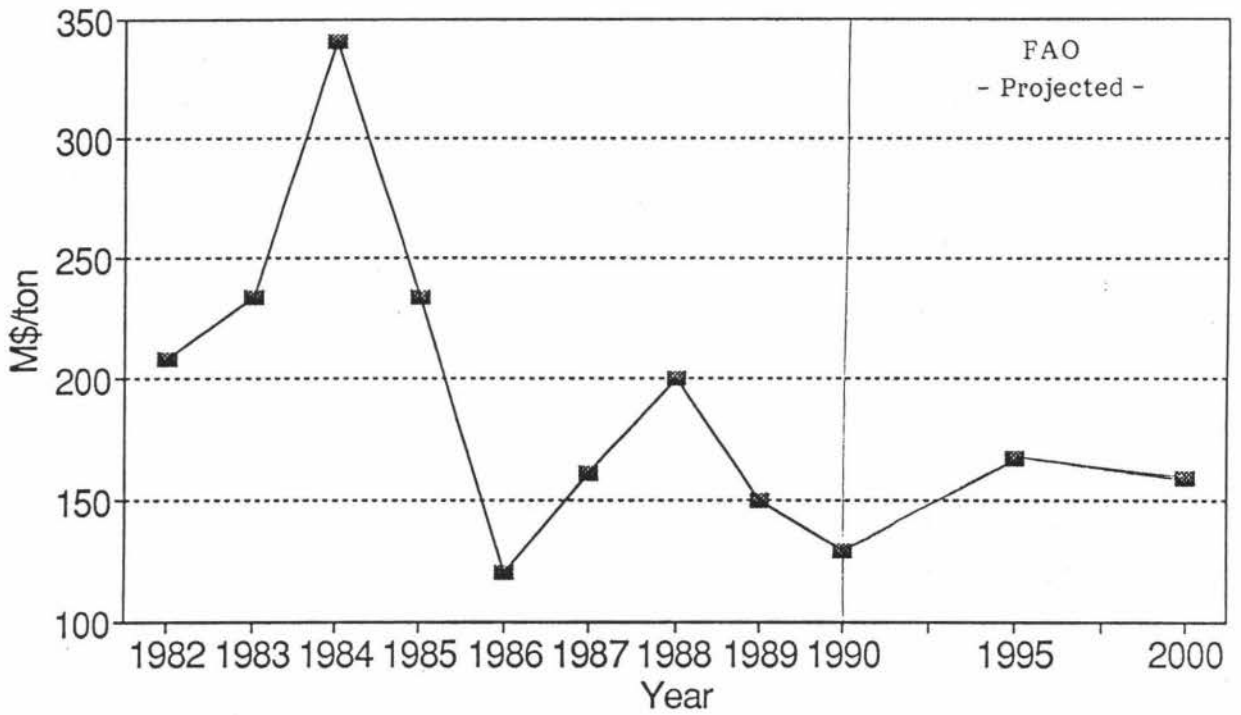
Uses of oils and fats are generally classified either as **edible** or **soaps** reflecting their two major uses: as edibles (ex. margarine, salad oils and shortenings) and as inedibles (ex. soaps, detergents, paints).

Note that most oils and fats are substitutable to varying degrees in end use between edible and inedible, with the largest proportional use of an individual oil / fat being for edible purposes.

Each of the oils and fats are influenced by their own specific technical and economic characteristics, as well as by relationships with other oils and fats. Technically, most oils and fats are highly substitutable (their individual prices reflecting this by sometimes tracking each other).

Fig. 5.2

## Oil Palm Prices (M\$/ton FFB)



Source : World Bank/FAO (1989)

In reality however, refining, transport and specific end-use requirements limit the range within which the individual oils and fats are actually substituted.

In this respect, it should be noted that some end use requirements may be politically inspired as in the case of the American Soybean Association lobbying for mandatory labeling of palm and coconut oil usage in products 'to inform the general public that such oils containing a greater proportion of saturated oils increase the risk of cardiac related ailments.' US soybean oil producers have lately been losing significant market share to palm oil producers who are more competitive oil producers. It should further be noted that if saturated fats do promote heart diseases (which has yet not been scientifically proven), the fat can be easily converted to an unsaturated form by dehydrogenation and/or undesirable fatty acid components removed by fractionation at relatively little cost.

Goddard and Glance (1989 found in a study on the demand for all oils and fats in US, Canada and Japan, that the aggregate demand functions were all price inelastic (-0.18 in the US, -0.21 in Canada and -0.18 in Japan). They also found that aggregate income elasticities were all around 0.4.

However, of the individual oils and fats, they determined that the only own price elastic oils were Palm Oil (US), Soybean (Japan), Groundnut (US and Canada) and Cottonseed (US and Canada).

Also, the cross-price elasticities were only elastic for Soybean-Palm oil, Soybean-Palm kernel, Corn-Palm oil, Soybean-Coconut and almost every other butter-oil elasticity, suggesting that for these oils and fats there is a certain degree of substitutability.

In general, however, they found that the inelastic cross-price elasticities give evidence of gross complementarity amongst the various oils and fats.

A priori assumption of the oils and fats market may be that there is more substitutability than is evidenced. It is interesting to note that, for markets that are interrelated on the demand side through substitution relationships, prices move together (particularly when movements in prices are initiated from supply 'shocks'). On the other hand, for oils that are gross complements, prices only move together when initiated by demand 'shocks'.

Goddard and Glance therefore conclude that the implications for major exporters of individual oils and fats may be that demand for their product (with the exception of oil palm and some others) is significantly more inelastic than a priori reasoning might suggest.

They also conducted a simulation for world trade in oils and fats if tariffs on soybean and groundnut oil imports into the US, Canada and Japan were removed, and found that a reduced demand in these oils would result with substitution by other price elastic oils such as palm oil.

Although at present, the imports by US, Canada and Japan of Malaysian (and Indonesian) palm oil is relatively very small compared to imports by the EEC, India, Pakistan and China, there does exist a possibility of much greater substitution of soybeans, groundnut and other oils in these developed countries (including in the EEC whose oil seed crops are protected by the infamous umbrella of the Common Agricultural Policy).

In this regard, it is relevant to point out the significant trade comparative advantage that tropical oil palm producers have over temperate soybean, groundnut and other vegetable oil producers.

Oil Palm starts yielding after only 3 years and continues producing for 25 years at relatively low variable costs (i.e. there is no recurring annual planting costs and production occurs year round). Even at current 1989 depressed price levels, largely due to the US and EEC import tariffs/barriers and export subsidies respectively, Malaysian (and especially Indonesian) oil palm producers continue to remain profitable.

In 1990, the global hectarage under mature oil palm exceeded a record 3 million hectares (double that in 1980). The mature area will rise by 7.5 % in Malaysia and 8.7 % in Indonesia in 1990. In absolute terms however, Malaysia's palm oil exports are triple that of Indonesia's.

Cocoa

The market for cocoa (used for the manufacture of chocolate products) is saturated with excess production and stagnant consumption. Since cocoa (unlike oil palm and to some extent, rubber) can be cultivated in geographically diverse regions, many countries rely on this crop to contribute to their foreign exchange earnings.

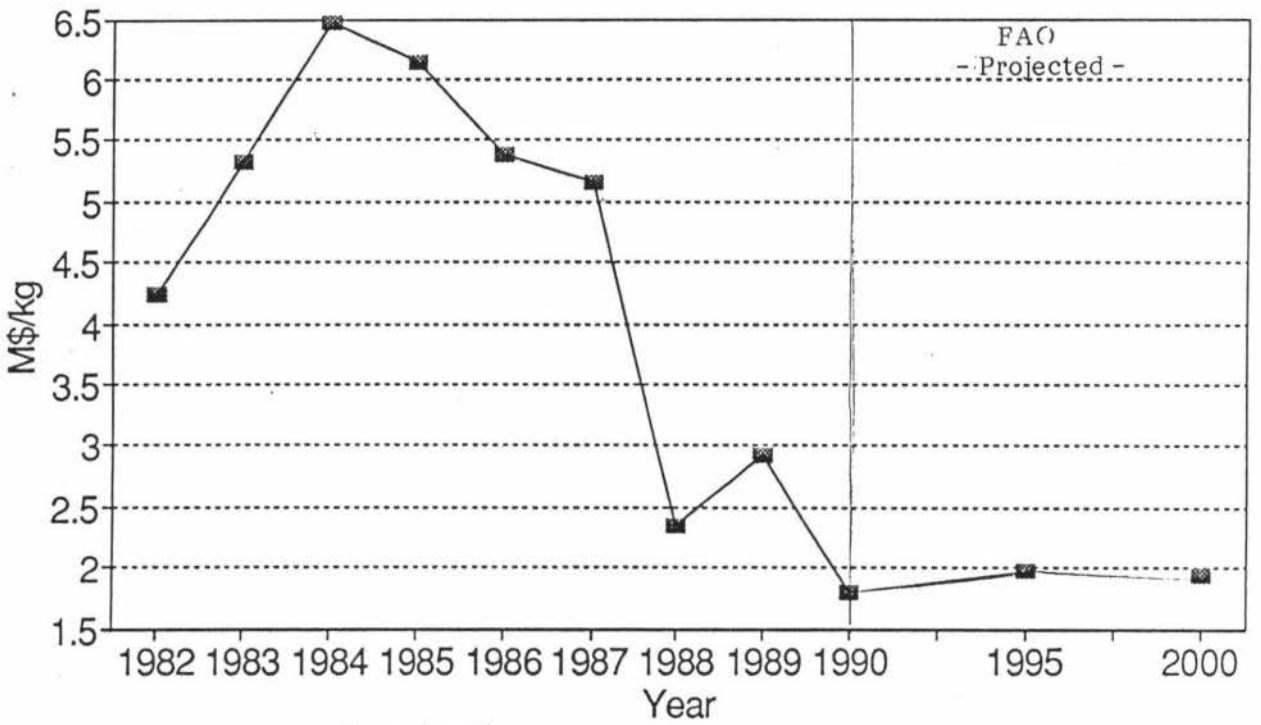
World production for the 1987/88 cocoa crop was a record 2.12 million tons (7 % greater than the 1986/87 outturn of 1.97 million tons).

Ivory Coast is the largest producer with an output of 700,000 tons in 1988, followed by Brazil at 402,000 tons. Malaysia, which entered the cocoa market relatively late, is fast becoming an important producer at 220,000 tons in 1988 (a 31 % gain over 1987's 167,000 tons).

Switzerland continued to have the worlds highest rate of cocoa consumption at 4.1 kg per capita, followed by Austria and W. Germany. The US averaged only about 1.8 kg per capita and the Soviets 0.7 kg per capita. Although the US is not a leading consumer on a per capita basis, it is the largest net importer accounting for more than 25 % of world cocoa imports.

Fig. 5.3

## Cocoa Prices (M\$/kg dry beans)



Source : World Bank/FAO (1989)

## 5.2 FACTOR INPUT MARKETS IN THE PRODUCER ECONOMIES

As rapid structural change is now a major feature of several S.E. Asian producer economies (including Malaysia, Indonesia and Thailand), it is important to consider the effect of the Manufacturing and Service sectors (which are growing very rapidly) on the more labour intensive agricultural sector which has traditionally been the mainstay of these nations economies.

'Resource-pull' effects on labour (and to some extent, on capital), to these Manufacturing and Service sectors are especially important in raising real wages (and the cost of capital).

In these section, these effects and the problems arising from them are examined for keeping the agricultural sector competitive in attracting resources.

The circumstances of perennial crop production differ considerably between the countries involved. Although the basic soils, climatic conditions and feasible yields may be similar for a particular crop (particularly Rubber) in each of the main producing locations, the relative endowments of land, labour and capital and other resources are not.

In Malaysia, land and labour have become scarce. Real wages and land prices / rent has tended to rise, while infrastructures of roads, railways, schools, welfare services and other related aspects have become increasingly abundant with advanced economic growth. In addition, lower level skills are generally well developed. Further, perennial crop plantings in the peninsula are concentrated in a relatively compact area close to points of exports, which decreases transport and marketing costs.

The effect of an increasingly important Manufacturing and Service sector in Malaysia (lately due to massive amounts of overseas investments), has led to significant urban migration and the accompanying rises in real wages in the traditional agricultural sector. The limited land available in Malaysia has also made land prices relatively much more expensive.

In contrast, on the huge island of Sumatra where most of Indonesia's plantation crops are grown, land is abundant and labour far cheaper than in Malaysia, but infrastructures are still very poor despite some very recent improvements.

As a result, the growth rates of planted hectarages to all perennial crops is greater in Indonesia than in Malaysia i.e. Indonesia has a greater comparative advantage in perennial crops than Malaysia. (This is particularly true for Oil Palm which grows very well under Sumatran climatic conditions.)

Thus far we have examined 'resource-pull' effects in an inter-sectoral context. There is however also an intra-sectoral reallocation of resources.

Rubber cultivation, which is the most labour intensive of the three perennial crops considered, has decreased in the last decade (in terms of land area, not output), and Oil Palm plantings have increased (in both Malaysia and Indonesia). Indeed, Oil Palm with its rapidly expanding output in the 1970's was a booming sector, exerting significant resource-pull effects on both land and labour. In the 1980's, Cocoa was a mini booming sector.

The estates that continued to cultivate Rubber responded to change by adopting output increasing management and capital intensive new technology.

Such new technology came in the form of higher yielding rubber trees and new tapping methods. While technical change has in the past been helpful in maintaining the economic viability of the remaining rubber estate area in Malaysia, it is significant that the parallel technical advances in Malaysian Oil Palm were that much greater, with notably that much larger increases in output.

More recently (in 1989), a new method of extracting latex from the rubber tree was developed in Malaysia which in commercial trials increased yields upto four to five times. The effect of this new technology on the world rubber market is thus expected to be quite significant and should help the natural rubber industry to bounce back as a desirable investment sector.

Chapter 6

MODEL FORMULATION

6.1 MODEL DEFINITION

The model as formulated is actually a 3 year model which is designed to allocate land to the various perennial crops in such a manner as to maximize the cash flows and the asset values of planted areas at the conclusion of the third year.

Formulation of a 25 year model that covers the optimum rotation ages of the perennial crops considered was not considered justifiable as crop allocation decisions are rarely made more than 3 years in advance. However, if the model were formulated for a longer period, it would be possible to get a picture of the cash flow situation over all the years modeled.

To reflect the ongoing nature of crop production after three years (the crop-land allocation planning horizon), either of two approaches is usually adopted. Either extra constraints, sometimes termed horizon posture constraints, are added to ensure a satisfactory horizon state is achieved (for example, in area planted); or alternatively, some form of post-horizon valuation is attempted to reflect the income generating potential of planted areas beyond the planning horizon. Both methods attempt to leave the plantation unit in a state which maximizes the net worth of that unit. The use of constraints achieves this by controlling the asset and/or liability structure (i.e. area planted), while post-horizon valuation achieves this by ensuring a 'healthy' post-horizon income stream. In the model formulated here, the latter approach is used in that, assets (i.e. planted areas) are valued at the end of the third year as the Terminal Value.

The mathematical structure of the model that is used in this study is defined as follows:

For each crop, yield is a function of labour, capital and fertilizer inputs...

$$Y_t = f ( L_t, K_t, F_t )$$

where, Y = Yield / Ha  
 L = Labour Intensity  
 K = Capital Intensity  
 F = Fertilizer Intensity  
 t = Year (t = 1, 2 or 3)

and the total crop produced is proportional to the area planted to that crop...

$$Q_t = Y_t \times N_t \quad \text{where, } Q = \text{Tot. Production}$$

N = Area planted to each crop

The objective of maximizing the present value of the cumulative annual net income obtainable from all crops planted subject to the conditions of resource (labour, capital, fertilizer and land) availability and cash flow accounting identities is denoted as:

$$\text{Max } \pi = \sum_t \sum_c [P_c \cdot Y_{ct} / (1+r)^t] - \sum_t \sum_c [(P_L \cdot L_{ct} + P_K \cdot K_{ct} + P_F \cdot F_{ct}) / (1+r)^t]$$

where, P = Price  
 Y = Yield/Ha  
 L = Labour  
 K = Capital  
 F = Fertilizer  
 c = Crops (Rubber, Oil Palm and Cocoa)  
 t = Years (1, 2 or 3)

For the intertemporal model developed here (for which the explanation of abbreviations can be found overleaf), this simplifies to ...

$$\text{Max } \pi = [CB_3 + \text{TermVal}] / (1+r)^3$$

such that in any year, t ...

Op Cash Bal:  $(SUK) + CB_{t-1} + \text{Borr} = \text{TotCost} + \text{Save}$

Taxable Inc:  $[\text{price}_c] \cdot (\text{CropSold}) + i_s \cdot (\text{Save}) = \text{TaxInc1} + \text{TaxInc2} + \text{TaxInc3} + \text{TaxDed}$

TaxDed/Loss:  $\text{FixCost} + [\text{cost}_{l,k,f}] \cdot (\text{Lab,Cap,Fert Usage}) + i_b \cdot (\text{Borr}) + \text{TaxLoss}_{t-1} = \text{TaxDed} + \text{TaxLoss}$

Exp:  $\text{TotCost} = \text{TaxDed} + \text{TaxLoss}$

TaxLim1:  $\text{TaxInc1} \leq 12,000$

TaxLim2:  $\text{TaxInc2} \leq 12,000$

BorrLim:  $\text{Borr} \leq 500,000$

Cl Cash Bal:  $CB = (1-t_1) \cdot \text{TaxInc1} + (1-t_2) \cdot \text{TaxInc2} + (1-t_3) \cdot \text{TaxInc3} + \text{TaxDed} + \text{Save} - \text{Borr} - \text{Consm}$

Consumption:  $\text{Consm} = \text{FixConsm} + (\text{MPC}) \cdot CB$

Yield:  $y_c \cdot (\text{Ha planted up to Year } t) \geq \text{Crop produced and sold (for each crop)}$

Labour:  $l_c \cdot (\text{Ha planted up to Year } t) \leq \text{Labour hired (for each crop)}$

Capital:  $k_c \cdot (\text{Ha planted up to Year } t) \leq \text{Capital bought (for each crop)}$

Fertilizer:  $f_c \cdot (\text{Ha planted up to Year } t) \leq \text{Fertilizer purchased (for each crop)}$

and such that over all years ...

Soil-Type STy:  $(\text{Ha planted up to Year } t) \leq \text{Land resource availability by Soil-Type}$

TermVal:  $\text{TermVal} = \sum_t AV_t \cdot (\text{Ha planted up to Year } t)$

[See Table 6.1 & 6.2 for a schematic representation of the above model formulation].

where,

$r$  = Discount Rate.

SUK = Start-Up Capital (specified in the first year only).

CB = after-tax Cash Balance.  
 i.e. the after-tax gross revenue less Borrowings repaid,  
 plus Savings withdrawn and less Consumption requirements.  
 (If CB is positive, cash is transferred to the Opening Cash  
 Balance row of the following year through the Cash Surplus  
 activity. If CB is negative, cash is transferred through  
 the Cash Deficit activity).

AV = Asset Value of planted areas.

TaxInc1 = Taxable Income in the first income tax bracket  
 (i.e. income subjected to a taxation rate of  $t_1$ ).

TaxInc2 = Taxable Income in the second income tax bracket  
 (i.e. income subjected to a taxation rate of  $t_2$ ).

TaxInc3 = Taxable Income in the third income tax bracket  
 (i.e. income subjected to a taxation rate of  $t_3$ ).

*Note: The total Taxable Income is the sum of all crop sales  
 plus interest on savings.*

TaxDed = Income allocated to cover tax deductible costs  
 (and which is not taxed).

TaxLoss = Costs not coverable by taxable income.  
 (transferred to the tax-deductions row of the following  
 year for consideration as a tax-deductible expenditure).

TotCost = Total Cost (i.e. FixedCost + VariableCost + Interest  
 on Borrowings or, TaxDed + TaxLoss).

Save = Savings  
 $i_s$  = Savings Rate

Borr = Borrowings  
 $i_b$  = Borrowing (Lending) Rate

Consm = Consumption (i.e. Fixed plus Variable Consumption).  
 Variable Consumption is specified as a percentage of  
 the after-tax Cash Balance, CB i.e. the MPC.  
 Note:  $MPC = 1 - MPS$  (implicitly).

TABLE 6.1

- Tableau showing Cash, Taxation, Consumption &amp; Cropping Input Output Activities -

Obj Fn Weights (in Final Year Only):													$1/(1+r)^t$	$1/(1+r)^t$		
Constraint	Supply	Activities			Tax Transfers					Emp	Borr	Save	Consm	Cash Transfer		Term Val
		Crop Soil	Sell O/put	Buy I/put	Tax1	Tax2	Tax3	Tax Dedct	Tax Loss					Sur	Def	
-in each year, the following constraints and activity coefficients hold:																
Op Cash Bal	Start-Up =									1	-1	1			(-1)	(+1)
Tanable Inc	0 =		-Price		1	1	1	1								
Tax Dedct	Fix Cost =		-V.Cost					1	1					-ib		
Tan Lim 1	12,000 $\geq$				1											
Tan Lim 2	12,000 $\geq$					1										
Expenses	0 =							-1	-1	1						
Borr Lim	Borr Lim $\geq$										1					
Cl Cash Bal	0 =				-(1-t1)	-(1-t2)	-(1-t3)	-1			1	-1	1	1	-1	
Consumption	Fix Consm $\leq$												1		-MPC	
Output Yield	0 $\leq$ $y_t$		-1													
Input Lab	0 $\geq$ $(1,k,f)_t$															
Cap																
Fert																
-in the Final Year, the Terminal (Asset) Value & Soil Resource constraint are also included (with activity coefficients included for all years):																
Term Val	0 = $-AV_t$															1
Soil Type	Area $\geq$ $1_t$															

## Note:

V. Cost = Variable Cost of cropping inputs on a per unit basis (fertilizer, capital and labour).  
 F. Cost = Fixed Cost (Depreciation, Managerial and Office Maintenance expenses etc.)

MPC = Marginal Propensity to Consume (i.e. Variable Consumption) [= 0.01 or 1%].  
 Fix Consm = Fixed Consumption requirement [= \$ 10,000].

t1 = Tax Rate [= 0 or 0%] assessable on the first \$ 12,000 of tanable income.  
 t2 = Tax Rate [= 0.26 or 26%] assessable on the next \$ 12,000 of tanable income.  
 t3 = Tax Rate [= 0.35 or 35%] assessable on the remaining tanable income.

is, ib = Savings rate [= 0.05 or 5%] and Borrowing rate [= 0.05 or 5%] respectively.

In the first year, the Start-Up Capital is specified as \$ 1,000,000 in the RHS. This specification is not made in subsequent years, where the RHS is specified as 0.

Allowable (cumulative) Borrowing Limit in any year was specified as \$ 500,000.

The -1 coefficients bracketed are present in the Opening Cash Balance row for all years/periods except the initial year/period. It's role is to transfer in after-tax cash (minus consumption) from the Cash Balance row of the previous year to the Opening Cash Balance row of the subsequent year (i.e. in the same column).

Any tax loss is transferred to the Tax Dedct / Loss of the following year for consideration as a tax deductible item. In the final year, any tax loss are inputted into the Terminal Value row for tax deduction against future income streams beyond the land allocation horizon.

## 6.2 INPUT-OUTPUT COEFFICIENTS IN THE MATRIX

### 6.2.1 Objective Function

As discussed previously in Ch.3 (3.2.3), the Objective function is specified as:

1. maximization of tax-free cash available at the end of the 3 year land allocation horizon, which implicitly maximizes Cash Flows (i.e. Cash Transfers) in each of the three years.
2. maximization of the value of assets (tree / palm plantings) owned by the plantation at the end of the land allocation horizon, and

The Objective Function of the intertemporal crop allocation model therefore maximizes profitability in present value terms and appears as:

$$\text{Max } \pi = \phi_1. (CB) / (1+r)^t + \phi_2. (E_t.AV) / (1+r)^t$$

where,  $\pi$  = Profits (in Present Value terms).

CB = Final (and annual) tax-free Cash Transfers / Flows  
i.e. the Year 3 Cash Balance.

$E_t.AV$  = Tot.Asset (Terminal) Value in Final Year (Year3).

$\phi_n$  = Weights placed on the various objectives.  
In the model, equal weights were placed  
on both objectives i.e.  $\phi=1$ .

### 6.2.2 Constraints

#### Cash, Taxation & Consumption Restraints

All cropping activities contributing to the cash-flow are measured in units per hectare; while all other activities and restraints are measured in dollar units. [See Table 6.1].

All activities requiring cash (for example, for payment of fixed and variable costs as well as for savings), will have a positive coefficient in the Opening Cash Balance row. In contrast, all activities supplying tax-free cash (such as borrowings and cash transfers from previous years), will have a negative coefficient.

All activities that supply cash to pretax cash receipts in the Taxable Income row (for example, by the sale of crop produce and by interest on savings) have a negative coefficient, which is then transferred through the tax transfer activities to the tax-free cash Closing Cash Balance row. The cash in the tax-free Closing Cash Balance row is then transferred to the Opening Cash Balance row of the subsequent year by the Cash Transfer activities after Consumption removals are carried out (and after borrowings have been repaid and/or savings withdrawn).

The tax deduction / loss row sums all costs, depreciation, as well as interest on borrowings for allocation as either a tax-deduction or tax-loss (the latter in the case where total expenses cannot be covered by income). The tax-deductions transfer activity transfers to the tax-free cash Closing Cash Balance row, an amount equal to the total tax-deductible expenditures to which income must be allocated, while any tax-loss is transferred to the Tax Deductions row of the subsequent year for consideration as a tax-deductible item.

The taxation rows and activities are structured in a way so as to tax income progressively. The first \$ 12,000 of income is not taxed, while the next \$ 12,000 is taxed at a rate of 26 %. Any income above \$ 24,000 is taxed at a rate of 35 %.

Marginal Tax Rates

Assessable Income	Income Tax	Consumption Tax	Tot. Tax	After-tax Income factor
<u>Tax Deductions:</u>				
10 % of Borrowings				
Depreciation \$ 500	- free of all tax	-		1.00
<u>Taxable Balance:</u>				
\$ 1 - \$ 12000	0	0	t1= 0	1.00
\$ 12000- \$ 24000	0.26	0	t2= 0.26	0.74
\$ 24000- & above	0.35	0	t3= 0.35	0.65

From the supply of tax-free cash in the Closing Cash Balance row of any period, a fixed dollar amount must be withdrawn to cover the fixed consumption requirements of the firm. In addition, a percentage of the tax-free cash income (1%) is channeled for consumption purposes as dictated by the firms Marginal Propensity to Consume (MPC). It is the remaining cash amount (which reflects the firms Marginal Propensity to Save (MPS) or Invest, that is actually transferred to the subsequent year in the Opening Cash Balance row through either Cash Transfer activities (Cash Surplus or Cash Deficit) after debts are repaid and savings are withdrawn. (If this cash amount is negative, i.e. the Cash Deficit activity is used to transfer the cash balance, borrowing is induced in the subsequent year).

The Savings activity allow annual savings and withdrawals and can therefore implicitly transfer tax-free cash from one year to the next (through the cash transfer activity), as well as pay a 5 % rate of return into pretax cash receipts.

The Borrowings activity allows the firm to borrow and repay cash each year at an interest rate of 5 %. Borrowings are specified in the annual Borrowing Limit constraint as allowed up to a limit of \$ 500,000. Similar to the Savings activity, Borrowings are transferable from one year to the next through the cash transfer activity.

The Terminal Value row (in the final year of the planning horizon only) allows the value of the firm's assets in areas planted (accumulated over the previous years) to be accounted for in the final period (the third year). The calculation of these values are explained in the next section.

Derivation of Asset Values of Planted Areas

Asset values of an area planted to a particular perennial crop of age t at the end of the 3 year planning horizon, was derived by obtaining the Net Present Value (at the third and final year) of all the post-planning horizon income streams (i.e. income derived after the third year).

*Note that in the present context, assets do not include those in fixed supply over the planning period, such as land, buildings and machinery; but only that of perennial crop plantings. Thus the problem was to assign asset values to all perennial crop - soil type activities which could be in existence at the end of the planning period.*

Hence all perennial crop activities were assigned an asset value equal to the present value of future net revenue (after-tax) discounted from infinity, with crop replacement at the optimum time (i.e. at the age of 25 years).

That is,

$$AV = NR_{m+1}/(1+r) + NR_{m+2}/(1+r)^2 + \dots + NR_{m+n}/(1+r)^n + A$$

where,

AV = Asset Value

NR = annual Net Revenue (after-tax)

m = age (in years) of the crop at the end of the 3 year planning horizon.

m + n = the optimum replacement age of the perennial crops (25 years).  
[See Ch.3.2.2].

A = the present value (at year 3) over all crop production cycles of t years (\$/Ha):

$$A = [ [ Et NR/(1+r)^t ] / (1-e^{-rt}) ] / (1+r)^{t+1-m}$$

where, t = m + n = Opt. Rotation Age.  
e = 2.71828

If annual cropping activities are included, their asset values are simply computed as...

$$AV = NR/r$$

Asset Value calculations were computed with the help of a spreadsheet program using data presented in Appendix 2.

**Labour Restraints**

The labour activities may supply (and implicitly remove) labour in each year,  $t$ , as required by a particular cropping activity. (These activities are measured in Man-Year units).

Labour Input coefficients			
Restraint	Supply	Cropping Activities Requiring Labour	Hire Labour
Crop Labour	$0 \geq$	$E L_c$	$-1$

**Note:**

The labour requirements (on a Man Year per Ha basis) as reflected by the labour coefficient,  $l$  of each cropping activity is detailed in Appendix 3.

**Capital Restraints**

The capital activities may supply (and/or remove) capital in each year,  $t$ . (These activities are measured in Dollar units per year).

Capital Input coefficients			
Restraint	Supply	Activities Requiring Capital	Borrow Capital
Crop Capital	$0 \geq$	$E K_c$	$-1$

**Note:**

The capital requirements (on a Dollar per Ha per year basis) as reflected by the capital coefficient,  $k$  of each cropping activity is detailed in Appendix 3.

### Fertilizer Restraints

The crop fertilizer activities may supply fertilizer in each year, t to each crop - soil type. (These activities are measured in Metric Tons).

Fertilizer Input coefficients

Restraint	Supply	Activities Requiring Fertilizer	Buy Fertilizer
Crop Fertilizer	$0 \leq$	$E F_c$	-1

Note:

The fertilizer requirements (on a Man Year per Ha basis) as reflected by the fertilizer coefficient, f of each cropping activity is detailed in Appendix 3.

### Yield Restraints

The crop yields obtained in each year, t (except during the crops immaturity years), are sold through the crop selling activities. (These activities are measured in kg for Rubber and Cocoa and in FFB tons for Oil Palm).

Crop Yield Output coefficients

Restraint	Supply	Cropping Activities on various Soil Types				Crop Selling Activities				
		RuST1	RuST2	OPST1	OPST2	CoST1	CoST2	SellRu	SellOP	SellCo
RubberYld	$0 \leq$	$Y_{r1}$	$Y_{r2}$					-1		
OilPalmYld	$0 \leq$			$Y_{op1}$	$Y_{op2}$				-1	
CocoaYld	$0 \leq$					$Y_{c1}$	$Y_{c2}$			-1

Note:

The yield profiles (on a per Ha per year basis) as reflected by the yield coefficient,  $Y_{cn}$  of each cropping activity is detailed in Appendix 3. (The yield profiles for all crop-soil type activities assume a mean annual rainfall of 2000 mm with two dry seasons per year lasting two months each i.e. where monthly rainfall is less than 150 mm).

**Land Restraints** (specified once only)

All cropping activities on the various soil types have a +1 coefficient for the soil type on which they are planted and for all the years in which they can be planted.

-Land Resource Availability in Period t -

Supply		Cropping Activities by Soil Type (in Year t)					
		RuST1	RuST2	OPST1	OPST2	CoST1	CoST2
SoilType 1	100 Ha ≥	1		1		1	
SoilType 2	100 Ha ≥		1		1		1

Note

The input-output coefficients of the various cropping activities used in the model was based on the soil type's slope and textural characteristics (as these soil variables were considered most important in deciding on crop-land suitability). Appendix 1 shows the slope and texture of each soil type that is encountered in Malaysia.

Thus in the model, each combination of crop-slope-texture comprised a cropping activity and each slope-texture combination represented a land resource constraint.

**6.2.3 Activities**

**Cropping Activities**

These activities are included in each period to allocate land of different characteristics (i.e. different soil types), to the various perennial crops considered in this study at various times. The soils are classified according to their slope and textural characteristics and are specified in units of hectares. The soil slopes used in classification was Flat (F), Sloping (S1) and Steep (St); while the soil textures used were sand (S), Sandy-Clay (SC), Clay (C) and Peat (P).

**Labour, Capital & Fertilizer Use Activities**

Labour activities are included in the model for each year of the planning horizon, their purpose being to allow the annual hiring of labour at the existing wage rate specified in M\$ / Man-Year.

Similarly, Capital activities specified in dollar units are included in order to meet capital good expenditures.

Fertilizer use activities are also included as distinct from capital costs because fertilizer requirements vary by soil types (defined in this study only on the basis of slope and textural characteristics). However, the nutritional status of each soil type can be indirectly modelled in through the adjustment of the fertilizer input coefficient as fertilizer usage is inversely proportional to the soil nutrient status. Thus these activities allow the purchase of fertilizers at existing prices specified in M\$ / ton.

**Crop Selling Activities**

Crop selling activities are included in each period to permit all crop produced to be sold at expected market prices.

**Financial Activities**

a. Taxation Transfer Activities

Taxation transfer activities are included for each year, allowing the computation of progressive taxation payments to be closely approximated with various marginal tax rates (specific to the various income levels).

For example, if a marginal tax rate of 35 % is applicable, the approximate taxation transfer activity would take every \$ 1 (upto a certain limit) from assessable income at the end of each year, and deliver \$ 0.65 (1-1x0.35) into the periods after-tax cash balance account.

b. Tax-Deductions / Tax-Loss Transfer Activities

Since all tax-deductible expenditures (including depreciation and interest on borrowings) must be subtracted from pretax cash receipts before taxation is calculated, the tax-deductions transfer activities remove from pretax cash receipts (in the Closing Cash Balance row) in any one year, a sum of cash equal to variable production and fixed expenditures, plus interest on borrowings. The tax loss transfer activities move all tax deductible expenses that are not coverable by annual income to the tax-deduction row of the following year for consideration as a tax deductible item.

c. Borrowing Activities

The Borrowing activities allow cash to be bought at an interest rate of 5 % for planting investment purposes. In the model, borrowings are specified as repayable each year, but borrowings can again be made in the subsequent year, so effectively, long term borrowings are allowed. Specification in this manner enables annual interest to be computed.

d. Saving Activities

The Savings activities represent investment activities which allow surplus cash to earn interest at 5 %. Hence the programme can every year either save money at a 5 % annual rate of return, or reinvest money in the holding at a rate of return greater than 5 %.

e. Consumption Activities

This activity allows the firms fixed and variable consumption requirements to be met by removing a fixed amount of cash (\$ 10,000), as well as an additional percentage (1%) of periodic cash transfers (specified as the MPC) from the after-tax Cash Balance account.

f. Annual (tax-free) Cash Flow / Transfer & Final Assets Activities

These activities represent the annual Cash Flow situation as well as the final asset position of the firm at the end of the planning horizon respectively.

### 6.3 THE FORMULATED MATRIX

The general structure of the formulated matrix is illustrated in Table 6.2 .

[The detailed specification of the matrix that is used in the analysis is presented in Appendix 4.]



Chapter 7

RESULTS & ANALYSIS

This chapter is concerned with the presentation and interpretation of the computed solutions of the formulated model as presented in Ch 6. The GULP Linear Programming routine which employs the Simplex Algorithm was used to solve the problem. [See Appendix 5 for a listing of the computed results].

The basic issues that were examined are: given available resources (and those which can be made available), how should perennial crop production in a hypothetical plantation be organized (with respect to fertilizer, labour and capital requirement); and what planting pattern should receive priority (with respect to the allocation of the various land types to the various crops at various times), given that 100 Ha of each of the ten soil types considered are available for planting. These issues have been tackled with respect to the decision makers objective to maximize annual cash flows and final year asset values, the results being presented and interpreted below.

7.1 RESULTS

7.11 The Optimal Plan

The optimum plan generated by the Crop-Land Allocation Model is presented here. A discount rate of 5 % was used to transform all annual cash flows into present value terms (as the cost of agricultural capital is generally about 5 % in Malaysia). The model thus uses this agricultural lending rate as a proxy for the discount rate as well as the prevailing lending and borrowing rates. An institutionally determined wage rate and fertilizer / capital cost figure was also used.

The specified objective of maximizing the present value of final year cash and asset values (and therefore, also the annual cash flows) resulted in a plan that uses up the \$ 1 million start-up capital to pay for planting investment and operational costs in the first two years, in cocoa and oil palm, and part of the rubber planting programme in the third and final year of the model. Borrowings were only necessary in the final year at the maximum allowable (\$ 500,000) to finance rubber planting investments in that year on all remaining hectarages that entered the plan.

In the plan, 232.5 Ha of cocoa is planted (on sloping soils) together with 46.33 Ha of oil palm (on flat peat) in the first year.

In the second year, 300 Ha of oil palm is planted on the flat mineral soils together with an additional 53.66 Ha on flat peat. On the sloping soils, 67.5 Ha of cocoa is also planted.

And in the third year, the remaining 300 Ha of steep soils were planted with rubber.

Thus, of the total 1000 Ha available for planting in the plantation, Rubber and Cocoa takes up 300 Ha each (on the steep and sloping soils respectively), while Oil Palm takes up the remaining 400 Ha on the flat soils. [The specific allocation of crop by soil terrain and texture, and their year of allocation, is detailed below.

Crop-Land Allocation (Ha) in the Optimum Plan

Crop - Soil Type	Year			Tot.Area (Ha)
	1	2	3	
Rubber				
St S			100	
SC			100	
C			100	
P				
>Total:	0	0	300	300
Oil Palm				
F S		100		
SC		100		
C		100		
P	46.33	53.67		
>Total:	46.33	353.67	0	400
Cocoa				
Sl S	100			
SC	100			
C	32.5	67.5		
P				
>Total:	232.5	67.5	0	300
Total Ha Planted:				1000

The Total Costs (Expenses) that are incurred in meeting fixed costs (of \$ 100,000) and variable operational costs (planting, fertilizing, labour and capital costs etc) in each year for crops grown on the various soil types are the sum of the Tax Deduction and Tax Loss activities. These turn out to be \$ 196,222, \$ 497,800 and \$ 849,708 for the first, second and third year respectively. (The third year total cost figure of \$ 849,708 includes the 5% interest on borrowings of \$ 500,000 i.e. \$ 25,000). Note: The total cost figures also include the Tax Loss of the previous year that is carried over to the following year for consideration as a tax deductible expense. (Tax Loss in Year 1,2 and 3 are \$ 156,003.48, \$ 462,502.32 and \$ 849,708 respectively).

The following tables show the amount of labour, fertilizer and capital used and the costs that are incurred in the optimal plan:

Labour Usage Activities (Man-Years)

Crop	Year			Tot.Labour (Man-Year)
	1	2	3	
Rubber			5.01	5.01
Oil Palm	0.73	6.05	3.92	10.70
Cocoa	4.65	4.84	3.57	13.06
> Total:	5.38	10.89	12.50	28.77
Labour Cost: \$	16,140	32,670	37,500	86,310

Wage Rate = @ \$ 3000 / Man-Year or \$ 10 / Man-Day

Fertilizer Usage Activities (tons)

Crop	Year			Tot.Fert (tons)
	1	2	3	
Rubber			42	42.00
Oil Palm	30.58	264	264	558.58
Cocoa	153.45	198	198	549.45
> Total:	184.03	462	504	1150.03
Fertilizer Cost: \$	55,209	138,600	151,200	345,009

Fertilizer price = @ \$300 / ton

Capital Usage Activities (\$)

Crop	Year			Tot.Cap (\$)
	1	2	3	
Rubber			21000	21000.00
Oil Palm	2779.92	24000	24000	50779.92
Cocoa	22087.5	28500	28500	79087.50
> Total: \$	24867.42	52500	73500	150867.40

Thus the cumulative expenses (total cost) that is incurred over the three year plan can be broken down as:

Breakdown of Cash Expenditures (\$)

Cost Type	Year		
	1	2	3
Total Variable Cost:	96,222	223,660	262,200
Fixed Cost:	100,000	100,000	100,000
Tax Loss (t-1)	0	156,033	462,504
Int on Borr	0	0	25,000
Total Cost: (cumulative)	196,222	479,799	849,708

Since all the three perennial crops have an immaturity period of three years or more, no income is obtained in the three years modeled except in the case of oil palm areas that are planted in the first year (on peat), which begin yielding in the latter part of Year 3. The oil palm yield in Year 3 is however very small resulting in an income of only \$ 23,998.94 from crop sales from the 46.33 Ha of oil palm planted on flat peat in Year 1.

Crop Production / Selling Activities

Crop	Year			Tot. Crop Sold
	1	2	3	
Rubber (kg)				0
Oil Palm (tons)			185.32	185.32
Cocoa (kg)				0

Commodity Prices: Rubber :- M\$ 2.25 / kg dry rubber (RSS 1)  
 (Year 1-3) Oil Palm :- M\$ 129.50 / FFB ton  
 Cocoa :- M\$ 1.79 / kg dry bean

However, cash in the Opening Cash Balance accounts that is not used to cover fixed and operational costs in each of the first two years (\$ 803,777.60 in Year 1 and \$ 345,909.60 in Year 2) provided income as interest (@ 5%) when saved. Interest of \$ 40,186.98 and \$ 17,295.49 is realized in Year 1 and 2 respectively, and together with the income generated from oil palm areas yielding in Year 3 (i.e. \$ 23,998.94), are the only cash income realizable in each of the three years in the crop allocation planning horizon. (All income figures are the sum of the TaxInc1, TaxInc2, TaxInc3 and TaxDedct activities).

The annual Closing Cash balance account is the sum of all cash income and cost activities allocated to the various tax brackets (i.e. the TaxInc1, TaxInc2, TaxInc3, TaxDedct and TaxLoss activities), plus savings withdrawn, less borrowings repaid, and consumption requirements met. This is the amount that is transferred to the Opening Cash Balance account of the subsequent year as an annual cash flow (Cash Surplus or Cash Deficit).

Off the initial start-up capital of \$ 1 million, available for investment, \$ 825,709.40 is still available at the end of Year 1 for meeting fixed and operational expenses in Year 2. And at the end of Year 2, \$ 349,708.00 is available for investment in Year 3. The Closing Cash Balance account at the end of Year 3 is, however negative i.e. a cash deficit balance of \$ 489,120 exists, thus inducing borrowings in that final year of the land allocation horizon.

Together with the Terminal Asset values of all planted areas at the end of Year 3 (\$ 24,351,303.60), the final year (Year 3) cash balance of \$ -489,120.00 results in a total value of plantings at the end of Year 3 of \$ 23,862,184.60 in Year 3 dollars, or \$ 20,282,856.06 in present value terms that was specified in the objective function.

Cash Activities in the Optimum Plan

Activity	Year			
	1	2	3	
Start-Up	1,000,000			
+ OpCashBal	0	825,709.40	349,708.00	
+ Borr	0	0	500,000.00	
- Save	803,777.60	345,909.60		
- TaxLoss	156,033.50	462,504.30	849,708.00	
= TaxDedct	40,188.88	17,295.49	0	
+ TaxInc1	0	0	12,000	(pretax)
+ TaxInc2	0	0	12,000	(pretax)
+ TaxInc3	0	0	0	(pretax)
= CashInc	0	0	20,880.00	(after-tax)
+ Save	803,777.60	345,909.60	0	
- Borr	0	0	500,000.00	
- Consm	18,257.09	13,497.08	10,000.00	
= ClCashBal	825,709.40	349,708.00	-489,120.00	Cash Transfer
Terminal (Asset) Value:		24,351,303.60		
Tot. Value (Asset + Cash):		23,862,184.60		
- in Present Value terms:		<u>20,282,856.06</u>		ObjFn Value

OpCashBal is the ClCashBal of the previous year (i.e. the Cash Transfer).

Tot. Cost is TaxDed plus TaxLoss (and includes the interest on borrowings plus Fixed and Variable Costs).

All the TaxInc figures are in pretax terms (and includes interest on savings plus income from crop sales).

The CashInc figures are in after-tax terms.

Refer also to Appendix 5 (GULP solution output of the Optimum Plan).

### 7.12 Shadow Prices (Dual Values)

The Shadow Price (or Cost) indicates the amount by which the objective function value will increase (or decrease) by increasing an activity or resource availability by one unit, i.e. it reflects the opportunity or marginal cost associated with increasing an activity by an additional one unit as well as the marginal value product associated with increasing a resource by one unit.

The programming model increases the level of an activity or utilizes additional resources only as long as their marginal contribution to the objective function is at least as great as their marginal cost. In the optimal solution these two measures will be equalized for activities at levels greater than zero.

The shadow cost of the cropping activities indicate the amount the objective function value would be decreased by increasing its level by 1 Ha. Similarly, the shadow cost of the cash activities (ex borrowings or savings) show the effect of increasing its level by \$ 1.

*The shadow costs of all cropping and cash activities that comprise the optimal plan are presented in Table 7.1 a, together with their objective function ranges.*

The shadow price of the borrowing limit constraint in the third year indicates that for every additional dollar above the \$ 500,000 allowable for borrowing, the objective function value would increase by \$ 1.24 (in present value terms) from the \$ 20,282,856.06 in the optimum plan. Or if the start-up capital in the first years Opening Cash Balance account were increased by an additional \$ 1, the objective function value would have increased by \$ 2.57. Similarly, if cash injections were made into the Opening Cash Balance of the second and third year, the objective function value would have increased by \$ 2.30 and \$ 2.15 respectively. Thus as the shadow prices of these financial variables indicate that the money available for investment is tight, their investigation through sensitivity analyses is warranted.

The shadow price of the land utilization constraint indicates that the value of a hectare of flat land is between \$ 17,299 - 18,245, while that of a hectare of sloping land is between \$ 20,179 - 23,513, and that of a hectare of steep land is between \$ 14,987 - 15,021 (see Table 7.1 c). These land values reflect the extra income derivable from a hectare of a particular soil type when planted to the crop that gives the highest return (in present value terms) on that soil type.

*The shadow prices of all resource that are available for plantation investment are presented in Table 7.1 b and 7.1 c together with the resource ranges / limits for which the optimal plan (not the objective function value) is stable.*

TABLE 7.1 a  
CROPPING & CASH ACTIVITIES

Name	Level	Shadow Cost	Obj Fn Range		
			Lower	Upper	
YEAR 1					
RU F S	Z	0	9385.38	-INF	9385.38
RU F SC	Z	0	11046.28	-INF	11046.28
RU F C	Z	0	12463.23	-INF	12463.23
RU F P	Z	0	19543.73	-INF	19543.73
RU SL S	Z	0	8813.05	-INF	8813.05
RU SL SC	Z	0	13297.65	-INF	13297.65
RU SL C	Z	0	13283.20	-INF	13283.20
RU SL P	Z	0	1298.97	-INF	1298.97
RU ST S	D	0	0	-61.20	66.27
RU ST SC	Z	0	61.20	-INF	61.20
RU ST C	Z	0	136.00	-INF	136.00
RU ST P	Z	0	1298.97	-INF	1298.97
OP F S	Z	0	47.37	-INF	47.40
OP FS C	Z	0	96.53	-INF	96.53
OP F C	Z	0	114.22	-INF	114.22
OP F P	A	46.33	0	-38.93	0.70
OP SL S	Z	0	9385.53	-INF	9385.53
OP SL SC	Z	0	11493.37	-INF	11493.37
OP SL C	Z	0	9102.16	-INF	9102.16
OP SL P	Z	0	3292.13	-INF	3292.13
OP ST S	Z	0	7833.35	-INF	7833.35
OP ST SC	Z	0	6590.49	-INF	6590.49
OP ST C	Z	0	5347.63	-INF	5347.63
OP ST P	Z	0	3292.13	-INF	3292.13
CD F S	Z	0	1441.88	-INF	1441.88
CD F SC	Z	0	3632.33	-INF	3632.33
CD F C	Z	0	3059.43	-INF	3059.43
CD F P	Z	0	22067.13	-INF	22067.13
CD SL S	A	100	0	-184.45	INF
CD SL SC	A	100	0	-75.65	INF
CD SL C	A	32.5	0	-0.81	45.18
CD SL P	Z	0	3822.37	-INF	3822.37
CD ST S	Z	0	6019.45	-INF	6019.45
CD ST SC	Z	0	4259.95	-INF	4259.95
CD ST C	Z	0	5114.20	-INF	5114.20
CD ST P	Z	0	3822.37	-INF	3822.37
SellRu	A	0	0	-13.23	INF
SellOP	A	0	0	-761.74	INF
SellCo	A	0	0	-10.53	INF
RuFert	Z	0	473.32	-INF	473.32
OPFert	A	30.58	0	-58.98	1.06
CoFert	A	153.25	0	-1.23	68.45
RuLab	Z	0	18528.74	-INF	18528.74
OPLab	A	0.73	0	-2463.86	44.18
CoLab	A	4.65	0	-40.50	2258.97
RuCap	D	0	0	-2.76	0.95
OPCap	A	2779.92	0	-0.65	0.01
CoCap	A	22087.52	0	-0.01	0.48

Name	Level	Shadow Cost	Lower Obj	Upper Obj
TaxInc 1	Z 0	3.60	-INF	3.60
TaxInc 2	Z 0	4.20	-INF	4.20
TaxInc 3	Z 0	4.40	-INF	4.40
TaxDct	A 40188.88	0	-3.72	0.31
TaxLoss	A 156033.48	0	-0.51	0.54
TotCost	A 196222.36	0	-0.54	0.31
Borr	Z 0	0.01	-INF	0.01
Save	A 803777.64	0	-0.56	0.02
Consm	A 18257.09	0	-54.33	2.29
CshSur	A 825709.42	0	-0.54	0.02
CshDef	Z 0	0.02	-INF	0.02

YEAR 2

RU F S	Z 0	9317.38	-INF	9317.38
RU F SC	Z 0	10978.28	-INF	10978.28
RU F C	Z 0	12395.23	-INF	12395.23
RU F P	Z 0	18965.73	-INF	18965.73
RU SL S	Z 0	8745.05	-INF	8745.05
RU SL SC	Z 0	13229.65	-INF	13229.65
RU SL C	Z 0	13215.20	-INF	13215.20
RU SL P	Z 0	720.97	-INF	720.97
RU ST S	Z 0	0	-INF	0
RU ST SC	Z 0	0	-INF	0
RU ST C	D 0	0	-94.58	54.56
RU ST P	Z 0	720.97	-INF	720.97
OP F S	A 100	0	-47.40	INF
OP F SC	A 100	0	-96.53	INF
OP F C	A 100	0	-114.22	INF
OP F P	A 53.67	0	-0.70	38.93
OP SL S	Z 0	8490.37	-INF	8490.37
OP SL SC	Z 0	10634.07	-INF	10634.07
OP SL C	Z 0	8278.72	-INF	8278.72
OP SL P	Z 0	1475.24	-INF	1475.24
OP ST S	Z 0	6902.32	-INF	6902.32
OP ST SC	Z 0	5695.32	-INF	5695.32
OP ST C	Z 0	4488.32	-INF	4488.32
OP ST P	Z 0	1475.24	-INF	1475.24
CO F S	Z 0	2476.33	-INF	2476.33
CO F SC	Z 0	2958.28	-INF	2958.28
CO F C	Z 0	3243.88	-INF	3243.88
CO F P	Z 0	19956.58	-INF	19956.58
CO SL S	Z 0	184.45	-INF	184.45
CO SL SC	Z 0	75.65	-INF	75.65
CO SL C	A 67.5	0	-45.18	0.81
CO SL P	Z 0	1711.82	-INF	1711.82
CO ST S	Z 0	5353.90	-INF	5353.90
CO ST SC	Z 0	1894.40	-INF	1894.40
CO ST C	Z 0	3598.65	-INF	3598.65
CO ST P	Z 0	1711.82	-INF	1711.82

Name	Level	Shadow Cost	Lower Obj	Upper Obj
SellRu	A 0	0	-7.72	INF
SellOP	A 0	0	-444.39	INF
SellCo	A 0	0	-6.14	INF
RuFert	D 0	0	-899.79	389.38
OPFert	A 264	0	-942.77	1080.96
CoFert	A 198	0	-1086.43	1080.96
RuLab	Z 0	3266.82	-INF	3266.82
OPLab	A 6.05	0	-120.35	6711.90
CoLab	A 4.84	0	-9035.87	162.02
RuCap	A 0	0	-1.80	0.78
OpCap	A 24000	0	-10.37	3.60
CoCap	A 28500	0	-7.55	3.60
TaxInc 1	Z 0	1.30	-INF	1.30
TaxInc 2	Z 0	1.86	-INF	1.86
TaxInc 3	Z 0	2.05	-INF	2.05
TaxDct	A 17295.48	0	-1.34	0.18
TaxLoss	A 462504.32	0	-0.21	0.94
TotCost	A 479799.80	0	-0.22	0.18
Borr	Z 0	0.01	-INF	0.01
Save	A 345909.62	0	-4.51	0.01
Consm	A 13497.08	0	-433.59	2.14
CshSur	A 349708.02	0	-4.34	0.02
CshDef	Z 0	0.02	-INF	0.02

YEAR 3

RU F S	Z 0	9317.38	-INF	9317.38
RU F SC	Z 0	10974.03	-INF	10974.03
RU F C	Z 0	12930.73	-INF	12930.73
RU F P	Z 0	18455.73	-INF	18455.73
RU SL S	Z 0	8745.05	-INF	8745.05
RU SL SC	Z 0	13229.65	-INF	13229.65
RU SL C	Z 0	13215.20	-INF	13215.20
RU SL P	Z 0	210.97	-INF	210.97
RU ST S	A 100	0	-66.27	61.20
RU ST SC	A 100	0	-61.20	INF
RU ST C	A 100	0	-54.56	94.58
RU ST P	Z 0	210.97	-INF	210.97
OP F S	Z 0	622.23	-INF	622.23
OP F SC	Z 0	622.23	-INF	622.23
OP F C	Z 0	622.23	-INF	622.23
OP F P	Z 0	622.23	-INF	622.23
OP SL S	Z 0	8262.60	-INF	8262.60
OP SL SC	Z 0	10406.30	-INF	10406.30
OP SL C	Z 0	8050.95	-INF	8050.95
OP SL P	Z 0	397.47	-INF	397.47
OP ST S	Z 0	6674.55	-INF	6674.55
OP ST SC	Z 0	5467.55	-INF	5467.55
OP ST C	Z 0	4260.55	-INF	4260.55
OP ST P	Z 0	397.47	-INF	397.47

Name	Level	Shadow Cost	Lower Obj	Upper Obj
CO F S	Z 0	1795.13	-INF	1795.13
CO F SC	Z 0	2277.93	-INF	2277.93
CO F C	Z 0	2554.18	-INF	2554.18
CO F P	Z 0	18704.18	-INF	18704.18
CO SL S	Z 0	717.04	-INF	717.04
CO SL SC	Z 0	922.74	-INF	922.74
CO SL C	Z 0	824.14	-INF	824.14
CO SL P	Z 0	459.41	-INF	459.41
CO ST S	Z 0	3846.50	-INF	3846.50
CO ST SC	Z 0	387.00	-INF	387.00
CO ST C	Z 0	2091.25	-INF	2091.25
CO ST P	Z 0	459.41	-INF	459.41
SellRu	A 0	0	-1.25	INF
SellOP	A 185.33	0	-9.73	0.17
SellCo	A 0	0	-0.99	INF
RuFert	A 42	0	-2764.27	390.44
OPFert	A 264	0	-2184.67	390.44
CoFert	A 198	0	-12198.40	390.44
RuLab	A 5.01	0	-10911.17	3904.37
OPLab	A 3.92	0	-410.59	3904.37
CoLab	A 3.57	0	-11294.83	202.52
RuCap	A 21000	0	-5.53	1.30
OPCap	A 24000	0	-24.03	1.30
CoCap	A 28500	0	-84.75	1.30
TaxInc 1	A 12000	0	-0.30	INF
TaxInc 2	A 12000	0	-0.08	INF
TaxInc 3	Z 0	0	-INF	0.00
TaxDet	Z 0	0.55	-INF	0.55
TaxLoss	A 849708.02	0	-0.56	0.35
TotCost	A 849708.02	0	-3.35	0.35
Borr	A 500000	0	-1.24	INF
Save	Z 0	1.27	-INF	1.27
Consm	A 10000	0	-INF	0.85
CshSur	Z 0	0.01	-INF	0.86
CshDef	A 489120	0	-0.85	-0.84
* TermVal	A 24351303.60	0	0.85	0.97

KEY:

Cropping Activities (in Ha) are denoted as CxSTy t where, C= Crop (Ru-Rubber, OP-Oil Palm or Co-Cocoa); and ST = Soil Type (ex F S = Flat Sand, Sl SC = Sloping Sandy Clay and St C = Steep Clay). ['t' refers to the time period (year) to which the activity is dated].

Note that yield data was included in the model only for F P i.e. Flat Peat soils on which only oil palm can be grown. Thus crops on Sl P and St P are redundant and no soil resource was specified for them within the model.

TABLE 7.1 b

CAPITAL RESOURCE UTILIZATION

Name	Slack	Shadow Price	Lower Lim	Limit	Upper Lim
<b>CAPITAL RESOURCES</b>					
<u>YEAR 1</u>					
OpCashBal	E 0	2.57	970,289.70	1,000,000	1,061,705.56
TaxInc	E 0	5.88	-11,601.58	0	24,095.42
TaxDed	E 0	-6.17	77,051.98	100,000	111,049.12
Exp	E 0	-2.57	-61,705.56	0	29,710.30
TaxLim 1	L 12,000	0	0	12,000	INF
TaxLim 2	L 12,000	0	0	12,000	INF
BorrLim	L 500,000	0	0	500,000	INF
ClCashBal	E 0	2.28	-34,073.17	0	70,766.85
Consp	G 0	-2.28	-8,374.70	10,000	44,073.17
Ru Fert	L 0	1,379.55	-0	0	0
OP Fert	L 0	1,852.87	-36.83	0	30.58
Co Fert	L 0	1,852.87	-36.83	0	76.49
Ru Lab	L 0	0	-0	0	INF
OP Lab	L 0	18,528.74	-1.20	0	0.73
Co Lab	L 0	18,528.74	-3	0	5.65
Ru Cap	L 0	6.18	-11,049.12	0	0
OP Cap	L 0	6.18	-11,049.12	0	2,779.92
Co Cap	L 0	6.18	-11,049.12	0	22,948.02
Ru Yield	G 0	-13.23	-10,709.07	0	0
OP Yield	G 0	-761.74	-186.07	0	0
Co Yield	G 0	-10.53	-13,461.13	0	0
<u>YEAR 2</u>					
OPCashBal	E 0	2.30	-33,735.82	0	70,066.19
TaxInc	E 0	3.43	-18,469.69	0	38,362.11
TaxDed	E 0	-3.60	63,464.66	100,000	117,591.22
Exp	E 0	-2.30	-70,066.19	0	33,735.82
TaxLim 1	L 12,000	0	0	12,000	INF
TaxLim 2	L 12,000	0	0	12,000	INF
BorrLim	L 500,000	0	0	500,000	INF
ClCashBal	E 0	2.13	-37,126.26	0	77,107.84
Consp	G 0	-2.13	-3,542.10	10,000	47,126.26
Ru Fert	L 0	1,080.96	-58.64	0	0
OP Fert	L 0	1,080.96	-58.64	0	121.78
Co Fert	L 0	1,080.96	-58.64	0	121.78
Ru Lab	L 0	7,542.76	-0	0	1.67
OP Lab	L 0	10,809.58	-2.40	0	6.05
Co Lab	L 0	10,809.58	-2.67	0	4.71
Ru Cap	L 0	3.60	-17,591.22	0	0
OP Cap	L 0	3.60	-17,591.22	0	24,000.00
Co Cap	L 0	3.60	-17,591.22	0	28,500.00
Ru Yield	G 0	-7.72	-17,049.83	0	0
OP Yield	G 0	-444.39	-296.23	0	0
Co Yield	G 0	-6.14	-21,431.35	0	0

Name	Slack	Shadow Price	Lower Lim	Limit	Upper Lim	
<u>YEAR 3</u>						
OpCashBal	E	0	2.15	-36,758.68	0	76,344.39
TaxInc	E	0	0.55	-19,538.08	0	24,000.00
TaxDed	E	0	-1.30	23,655.61	100,000	136,758.68
Exp	E	0	-2.15	-76,344.39	0	36,758.68
TaxLim 1	L	0	0.30	0	12,000	31,538.08
TaxLim 2	L	0	0.08	0	12,000	31,538.08
BorrLim	L	0	1.24	461,306.65	500,000	580,362.52
ClCashBal	E	0	0.85	- INF	0	489,120.00
Consm	G	0	-0.85	-0	10,000	INF
TERM VAL	E	0	0.85	-24,351,303.60	0	INF
Ru Fert	L	0	390.44	-122.53	0	42.00
OP Fert	L	0	390.44	-122.53	0	254.48
Co Fert	L	0	390.44	-122.53	0	198.00
Ru Lab	L	0	3,904.37	-12.25	0	5.01
OP Lab	L	0	3,904.37	-12.25	0	3.92
Co Lab	L	0	3,904.37	-12.25	0	3.53
Ru Cap	L	0	1.30	-36,758.68	0	21,000.00
OP Cap	L	0	1.30	-36,758.68	0	24,000.00
Co Cap	L	0	1.30	-36,758.68	0	28,500.00
Ru Yield	G	0	-1.25	-10,666.67	0	0
OP Yield	G	0	-71.72	-185.33	0	150.87
Co Yield	G	0	-0.99	-13,407.82	0	0

Note: The Upper and Lower Limits / Range determine the range over which the VMP / MC of each resource is relevant.

TABLE 7.1 c

LAND RESOURCE UTILIZATION

Resource	Units	Quantity Available	Quantity Used	Shadow Price		Range	
				VMP (+)	MC (-)	Lower	Upper
<b>LAND RESOURCES</b>				<b>Land Value (\$)</b>		<b>(Ha)</b>	
F S	Ha	100	100	17,298.72		17.57	139.69
SC	Ha	100	100	17,808.72		17.57	139.69
C	Ha	100	100	18,074.77		17.57	139.69
P	Ha	100	100	18,244.77		46.33	139.69
SI S	Ha	100	100	20,179.08		65.40	116.66
SC	Ha	100	100	23,512.78		65.40	116.66
C	Ha	100	100	22,347.43		65.40	134.71
P	Ha	0	0		0	0	INF
St S	Ha	100	100	15,021.03		0	326.77
SC	Ha	100	100	15,004.34		0	326.77
C	Ha	100	100	14,987.03		0	326.77
P	Ha	0	0		0	0	INF
<b>Total:</b>	Ha	<b>1000</b>	<b>1000</b>				

## 7.2 SENSITIVITY ANALYSIS

The shadow costs of the cropping activities in particular are informative in that it tells us the amount by which the objective function values would have to be increased (through the increase in the Terminal (Asset) Value or the final year cash balance) for that cropping activity to enter the plan in that year.

*For instance, in Year 1, for each crop that could possibly be allocated to flat sandy soils, the rubber shadow cost is highest at \$ 9,385.38, followed by cocoa at \$ 1441.88 and oil palm at \$ 47.39.*

*Thus as oil palm has the lowest shadow or opportunity cost for allocation to flat sandy soils in the first year (as against rubber or cocoa), oil palm would be planted on this soil type in preference to the other two crops in the second year. In Year 2, oil palm is in fact allocated to flat sandy soils.*

The reason why all available hectarages are not planted in Year 1 is that additional income from interest from saving the unused portion of the start-up capital can also be used for meeting operational expenses in the following year. The exact timing of crop-land allocation would therefore depend on the benefits (marginal value product) of obtaining an additional proportion of unused start-up capital (or Closing Cash Balance) as opposed to the cost of delaying planting by one year (marginal cost). This in turn is a function of various factors - the amount of start-up capital available for investment, the savings, borrowings, discount rates; the wage rate, the cost of cropping operations, crop yields and commodity prices and / or of final year asset values.

In planning, it is important to know not only the most profitable combination of activity levels, but also the stability of the optimal plan in relation to data input assumptions and how it would vary in response to a change in resource base or product and input prices (or the specification of the objective function).

As varying these parameters (i.e. through conducting parametric analysis) could lead to different optimal planting patterns, in this section, the sensitivity of the optimum plan outlined earlier to various factors of major significance is examined.

a. Sensitivity of the Optimal Planting pattern to the amount of Start-Up Capital (supplied to the Opening Cash Balance of Year 1).

By conducting a number of optimization runs in which the start-up capital was varied from \$ 359,618 - 1,859,449, the sensitivity of the optimal planting programme and the associated objective function (or profitability) values as tabled below were obtained.

Crop Hectarages Planted (by year) given different levels of Start-Up Capital

Start-Up Capital (SUK) \$	Obj Fn Value \$ (PV)	Area Planted by Year (Ha)									Total Area Planted (Ha)
		Year 1			Year 2			Year 3			
		Ru1	OP1	Co1	Ru2	OP2	Co2	Ru3	OP3	Co3	
359,618	17,332,523							400	400	200	1000
375,048	18,175,061							300	400	300	1000
433,455	18,410,073						100	300	400	200	1000
491,861	18,642,769						200	300	400	100	1000
542,035	18,834,093					100	200	300	300	100	1000
592,208	19,025,413					200	200	300	200	100	1000
642,382	19,216,737					300	200	300	100	100	1000
692,555	19,408,457					400	200	300		100	1000
750,962	19,611,602					400	300	300			1000
842,378	19,865,265			100		400	200	300			1000
860,626	19,915,772		23.17	100		376.83	200	300			1000
952,042	20,158,556		23.17	200		376.83	100	300			1000
970,289	20,206,408		46.33	200		353.67	100	300			1000
BM 1,000,000	20,282,856		46.33	232.5		353.67	67.5	300			1000
1,061,706	20,441,629		46.33	300		353.67		300			1000
1,103,980	20,550,365		100	300		300		300			1000
1,182,749	20,748,267		200	300		200		300			1000
1,261,518	20,941,247		300	300		100		300			1000
1,340,286	21,132,446		400	300				300			1000
1,366,452	21,194,317		400	300	100			200			1000
1,392,617	21,256,186		400	300	200			100			1000
1,418,782	21,318,053		400	300	300						1000
1,459,230	21,386,192	100	400	300	200						1000
1,499,678	21,448,210	200	400	300	100						1000
1,540,126	21,502,749	300	400	300							1000
1,859,449	21,821,121	300	400	300							1000

NOTE: - BM = Base Model optimal plan (for which the detailed plan was presented earlier).

- Where Rubber entered the optimal plan, the crop was allocated primarily to steep soils. Similarly, where Oil Palm and Cocoa entered the optimal plan, they were primarily allocated to flat and sloping soils respectively.

Examination of the table indicates that when the Start-Up Capital, SUK is insufficient to plant crops on the total available hectarage of 1000 Ha in the first year (i.e. when the start-up capital is less than \$ 1,540,126), cocoa plantings are given priority over oil palm which is planted later. In turn, oil palm planting takes priority over rubber plantings. (An exception to this generalization occurs where oil palm is planted on peat (flat soils) as oil palm yields are very high if the water table in peat is optimally controlled. As a result, oil palm allocation to peat takes priority over some cocoa allocations). Thus as investment capital becomes more scarce, the crops which have a lower priority may be planted later in time.

However, if cash resources are so tight that the start-up capital is less than \$ 359,618, land normally allocated to cocoa is reduced. This occurs because cocoa plantings require a higher amount of capital during its immaturity period of 4 years (since the crop requires that shade trees be planted, intensive pest management be practiced, and usually high corrective fertilizer applications be made, *vis-a-vis* rubber and oil palm).

Cocoa planting receives the highest priority in the base model case simply because their yields and therefore net returns are highest, (followed by oil palm and rubber). Although its initial maintenance costs during immaturity is significantly higher than that of rubber and oil palm, its yields can be very high and uniform over its lifetime. In addition, the species matures relatively early at four years of age. (Oil Palm matures at three years while rubber matures in five years).

Oil Palm plantings, having the advantage of the shortest immaturity period and showing peak yields early in its rotation (at between the sixth to the tenth year), comes into the plan next.

Rubber plantings which have the distinct disadvantage of having the longest immaturity period and a high labour requirement during their maturity years (for tapping / harvesting), comes into the plan last.

*It should be noted however that although the optimal plans generated favour cocoa plantings over rubber and oil palm (because of its high and uniform yield profile), its yields can be very significantly reduced (for a few years in some cases) by pest infestations that are more likely in unfavourable climatic localities. Together with the extra expenses that can be incurred in such cases (through higher pesticide use and other pest management measures implemented), cocoa cultivation may not be as profitable as it might appear. In practice, plantation managers do limit the hectarage planted to cocoa should their estates be endowed with a significant amount of soils suitable for cocoa cultivation) to some percentage of their total plantation hectarage. Thus when applying this model in a non-hypothetical situation, a risk constraint restricting the maximum cocoa area plantable might need to be included in the formulated model to reflect the decision makers risk averseness.*

b. Sensitivity of the Optimal Planting pattern to Savings and Borrowing Interest Rates

The sensitivity of the optimal plan to changes in the savings and borrowing rates (which were both specified at 5 % in the base model), are presented below.

Sensitivity of Crop Hectarages Planted (by year) to Saving and Borrowing Interest Rates

-Int.Rates- Save Rate %	Borr Rate %	Obj Fn Value \$ (PV)	Area Planted by Year (Ha)									Total Area Planted (Ha)
			Year 1			Year 2			Year 3			
			Ru1	OP1	Co1	Ru2	OP2	Co2	Ru3	OP3	Co3	
3	5	20,160,085		23.2	193.75		376.8	106.25	300			1000
4	5	20,222,942		46.33	203.5		353.67	96.5	300			1000
5	BM 5	20,282,856		46.33	232.5		353.67	67.5	300			1000
5	6	20,276,348		46.33	228		353.67	72	300			1000
5	7	20,269,841		46.33	223.67		353.67	76.33	300			1000
4	6	20,216,185		45.2	200		354.8	100	300			1000
3	7	20,145,536		23.2	184.5		376.8	115.5	300			1000

NOTE: - BM = Base Model optimal plan (for which the detailed plan was presented earlier).

- Where Rubber entered the optimal plan, the crop was allocated to steep soils. Similarly, where Oil Palm and Cocoa entered the optimal plan, they were allocated to flat and sloping soils respectively.

The plans generated from optimization runs in which the savings and borrowing rates were varied between 5% - 3% and 5% - 7% respectively, show that the effect of the savings rate is of greater (although small) significance than the borrowing rate when the start-up capital is \$ 1 million.

If the savings rate were reduced from 5% to 4%, the objective function value decreases by \$59,914. On the other hand, if the borrowing rate were increased by the same magnitude from 5% to 6%, the objective function value decreases by only \$ 6,508 (or about one tenth of the reduction caused by reducing the savings rate).

The effect of changes in the saving and borrowing interest rates on the planting programme (for the scenarios tested), show up in the timing and extent of planting cocoa and to a lesser extent, oil palm. The rubber planting programme was not affected.

As the savings rate is reduced from 5% to 4% and/or the borrowing rate is increased from 5% to 6%, the cocoa hectareage that is planted in the first year (in the base model case), drops. If this change is made separately, the cocoa area planted in the first year drops to a greater extent from reducing the savings rate (from 232.5 Ha to 203.5 Ha) than from increasing the borrowing rate (from 232.5 Ha to 228 Ha). If however, this change is made simultaneously, the cocoa hectareage that is planted in the first year drops from 232.5 Ha to 200 Ha.

Plantings of oil palm that would normally be carried out in the first year in the base model case (46.33 Ha), are reduced only if the savings rate is reduced to a greater extent (down to 3%), together with further decreases in the cocoa hectareage planted in the first year.

In all cases, the reduction in crop areas planted in the first year by the unfavourable changes to the savings and borrowings rates are made up by increased plantings in those crop(s) in the following year.

c. Sensitivity of the Optimal Planting pattern to Product (Commodity) Prices

A sensitivity analysis of the optimal plan to commodity prices is only meaningful if optimization runs are made to indicate the stability of the base model plan to changes in price expectations with respect to a single commodity.

The fact that the large variation in prices observed for all three commodities considered in this study are not cross-correlated, makes it difficult to derive deterministic optimal plans.

In the authors opinion, the price projections used to run the base model (as forecasted by the FAO) reflect quite well the current (and therefore expected) world market conditions of the commodities concerned. If planting decisions are to be made on the basis of expectations based on current market conditions, then the base model should be able to serve this purpose adequately.

However here, a commodity price sensitivity analysis is conducted in order to obtain some idea of the direction and extent of crop hectareage changes that should be made to the base model plan if price expectations are more optimistic or pessimistic than that assumed in the base model.

Optimistic (high) and Pessimistic (low) commodity prices are taken (for the whole 25 years of the crops rotation) as the highest and the lowest prices of each commodity in the last three years (1988 - 1990). Thus the commodity prices used in the analysis are:

		Low	High
Rubber	(M\$/kg)	2.00	3.00
Oil Palm	(M\$/ton)	100.00	200.00
Cocoa	(M\$/kg)	1.50	3.00

If the decision makers price expectations are different from that assumed in the base model, the following table should provide some indication on the direction, if not the exact extent, of changes that should be made to the base model plan.

Sensitivity of Crop Hectarages Planted (by year) to Commodity Prices

Commodity Prices (\$)	Obj Fn Value \$ (PV)	Area Planted by Year (Ha)									Total Area Planted (Ha)
		Year 1			Year 2			Year 3			
		Ru1	OP1	Co1	Ru2	OP2	Co2	Ru3	OP3	Co3	
Low Ru	20,282,856		46.33	232.50		353.67	67.50	300			1000
Low OP	18,416,149			400	54			246	100	200	1000
Low Co	17,549,352		400		300	84			216		1000
BM	20,282,856		46.33	232.50		353.67	67.50	300			1000
High Ru	23,974,083	100	46.33	154.50	300	353.67	45.50				1000
High OP	24,234,204		301.50			98.50	300	200	100		1000
High Co	23,453,418			327		100	73	100		400	1000

NOTE: - BM = Base Model optimal plan (for which the detailed plan was presented earlier).

The plans generated indicate that significant changes in crop hectarages planted and profitability (from the base model plan) can result from changes in commodity price expectations for a single commodity over a long time frame. This therefore makes the base model plan quite unstable in the face of sustained wide differences in price expectations in a single commodity. (Note however that there was no effect of low rubber prices on the base model plan).

With the exception of the plan generated in the low cocoa price scenario (which resulted in no cocoa being planted at all), all other scenario's tested resulted in a plan which involved the planting of all three crops to some extent.

d. Sensitivity of the Optimal Planting pattern to Labour wage rates

The sensitivity of the optimal plan to changes in the wage rate is presented here.

The wage rate used in the base model case was representative of the current Malaysian labour market situation and was taken at \$ 10 / Man-Day (or \$ 3000 / Man-Year). An optimization run was also made for a higher wage rate of \$ 15 / Man-Day (or \$ 4365 / Man-Year) which reflects movements of agricultural labour to the faster growing non-agricultural sectors in the Malaysian economy, thus pushing up agricultural wage rates.

An optimization run was also made for a lower wage rate of \$ 5 / Man-Day (or \$ 1455 / Man-Year) which reflects the Indonesian labour market. It would then be possible to judge the magnitude in comparative advantage arising from lower labour costs that Indonesia enjoys over Malaysia in the production of these perennial crops.

In the following table, the plans generated from optimization runs where the wage rate was varied, is presented.

Cropping Plan (Ha) under various Wage Rates (M\$ / Man-Day)

	(I'sia) \$ 5	<----- (M'sia) -----> \$ 10                      \$ 15	
<u>YEAR 1</u>			
Rubber			
Oil Palm	23.2	46.33	
Cocoa	251.6	232.5	179.2
<u>YEAR 2</u>			
Rubber	300		
Oil Palm	376.8	353.67	400
Cocoa	48.4	67.5	120.8
<u>YEAR 3</u>			
Rubber		300	100
Oil Palm			
Cocoa			200
<u>TOTAL CROP HA</u>			
Rubber	300	300	100
Oil Palm	400	400	400
Cocoa	300	300	500
> Total Ha:	1000	1000	1000
Obj Fn Value: \$	25,067,066	20,282,856	15,856,595

As the above table illustrates, the optimum plan obtained under the various wage rate scenarios reflect the shift away from Rubber plantings in favour of Cocoa as wage rates rise above \$ 10 / Man-Day. This shift from rubber cultivation occurs because harvesting latex is very labour intensive.

Thus where the Malaysian wage rate is \$ 10 / Man-Day (the current situation and the base model scenario), 300 Ha each of cocoa and rubber would be planted with 400 Ha of oil palm (cocoa plantings receiving the highest, and rubber the lowest priority).

However, as labour shortages in Malaysia get more acute (and wage rates rise to \$ 15 / Man-Day), cocoa begins to be planted on soils that are normally allocated to rubber at labour rates of less than \$ 10 / Man-Day i.e. cocoa plantings are also made on steep soils even though their yields on such soils are not as high as on sloping soils.

In the case of Indonesia, where wage rates are typically less than \$ 5 / Man-Day, the optimal planting programme is very similar to that of Malaysia where the wage rates are \$ 10 / Man-Day (the only difference being that slightly more areas are planted to cocoa and rubber earlier in the three year crop allocation horizon).

e. The Optimal Planting when only Rubber and Oil Palm plantings are permissible

As it is often not possible to plant cocoa at all due to the high acidity of most 'old, weathered' tropical soils, it is often the case that planting options are restricted to rubber and oil palm only. (Cocoa can generally only be planted on the 'newer' volcanic soils or *entisols*).

Thus here, the optimal plan generated from the base model modified so as to not allow cocoa to be allocated is presented. It would therefore be possible to identify to what crop (rubber or oil palm), the soils that would have otherwise have been planted to cocoa, are allocated to.

The table below presents, for comparison purposes, the optimal plan generated from the base model (which allows cocoa to be planted) to that generated by a modified version which does not permit cocoa plantings.

As the result of the respective plans show, the sloping soils that are normally allocated to cocoa, would have been planted to oil palm should for agronomic reasons, it not be possible to plant cocoa to such soils.

Cropping Plan (Ha)			
		Cocoa planting allowed	Cocoa planting not allowed
<u>Rubber</u>			
St	S	100	100
	SC	100	100
	C	100	100
<u>Oil Palm</u>			
F	S	100	100
	SC	100	100
	C	100	100
	P	100	100
Sl	S		100
	SC		100
	C		100
<u>Cocoa</u>			
Sl	S	100	
	SC	100	
	C	100	
	P		
<u>TOTAL CROP HA</u>			
Rubber		300	300
Oil Palm		400	700
Cocoa		300	
> Total Ha:		1000	1000
Obj Fn Value: \$		20,282,856	17,549,352

Sensitivity analyses to changes in factors such as the fertilizer cost, the marginal propensity to consume and the taxation rates could also have been carried out. But as the value of these parameters are not likely to change to the extent of having a major effect on the optimal plan, they were not conducted.

Chapter 8

DISCUSSION

8.1 AN ASSESSMENT OF THE MODEL'S ACHIEVEMENTS

Model Validation

In the construction of a programming model with a large number of equations and variables (which in this study numbered 76 constraints, bounds and reconciliation rows and 178 activities), tests should be carried out to validate the model as a tool for normative analysis for decision making purposes.

Since land is one of the most basic inputs to agricultural production in this study, the land rental (valuation) test provides a good indication of the models accuracy in valuing agricultural production and its associated inputs. In turn, this means that it is a test of the accuracy of the models structure for transforming inputs into outputs.

The test consists of comparing the land rental (value) figure that is generated by the model, with actual market values.

The land value figure generated by the model is the shadow price on the land constraints. Thus for the model developed in this study, land valuation figures are generated for each soil type whose resources have been specified. These turned out to range between \$ 14,987 - \$ 23,512 per hectare for the various soil types.

Since these generated land values are broadly comparable with current agricultural land prices in the Malaysian market (approx \$ 17,000 / Ha), the model can be considered reasonably accurate in transforming inputs into outputs efficiently.

*Note: The market price of land was taken to be \$ 17,000 per hectare as this was the land value at which a large plantation recently changed hands in Malaysia. (Source: Dunlop Sdn. Bhd. Annual Report 1989).*

Thus, the results obtained from the perennial cropping investment model developed in this study do provide an indication to a rational plantation manager on how he should carry out his planting programme to meet his objectives.

It should however be realized that planting investment plans generated in this manner are subject to major alterations depending on various exogenous factors. The effect of changes in the amount of start-up capital available to the decision maker for planting investment purposes, of saving and borrowing rates, and of wage rates expected over the planning horizon have been shown to be significant.

The model also proved to be very sensitive to commodity prices and so indicates the importance of "getting the price right." Wrong prices lead to wrong planting plans which are difficult and costly to change, especially where perennial crops are concerned.

Other factors that have not been examined in detail in this study, such as the fertilizer and capital costs expected over the land allocation horizon would also be likely to affect the optimal plan to some extent.

Therefore, it is imperative that the decision maker consider the current market situation (Chpt 5) with respect to obtaining some idea of what future prices of the commodities concerned are likely to be, as well as to the supply and cost of the more important inputs in future years.

As such, the models continued success as a decision making tool is to a large extent dependent on making modifications to reflect technological changes, altered price expectations etc.

Modifications to the model can also be made to reflect past experiences. Say that in the locality of the plantation, cocoa trees have proved to be very susceptible to pest damage, perhaps because the micro-climate is favourable to a particular pest. The decision maker may then wish to place a limit on the cocoa hectarage that enters the plan as a risk aversion measure, even though it might be the most profitable crop to plant on the soil type that the plantation is endowed with. Additional constraint(s) can then be included in the model to limit the total cocoa hectarage either to some specific hectarage or to a percentage of the total plantable area.

## 8.2 AN ASSESSMENT OF THE MODEL'S LIMITATIONS

### a. Limitations of the Model Data

The accuracy with which future prices and market conditions (not only for the commodities concerned, but also for the labour and capital inputs required for the production process), plays an important role in determining the usefulness of the plan.

As already discussed, resource pull effects on labour and capital inputs by other sectors of the economy make it difficult to predict wage rates and capital costs in future years with any degree of certainty.

In addition, the problem of formulating market condition expectations for the perennial crops produce is aggravated by the international and intertemporal context of the problem. The justification for assuming that current prices (or even World Bank forecasted prices, that were used in this study) will prevail in the future with minor adjustment for cyclical variations involves the assumption of a competitive price that will clear the market. This assumption clearly does not take international trade, quota agreement and tariff structures into consideration, nor does it take into account the unpredictable nature of world markets into which commodities must be sold. This is particularly true for Rubber and Oil Palm whose produce have substitutes.

Hence, when evaluating the optimal plan generated by a model, it may prove critical to modify it by taking the decision maker's subjective expectation of the global commodity market and resource (factor input) market into consideration. It is for this reason that the current market situation for the commodities and the resources (particularly labour) was reviewed in an earlier chapter (Chpt. 5).

Likewise, it may also prove important to study the effect of year-to-year yield variability arising from agro-climatic variation in the production process. For this reason too, crop production characteristics were examined earlier (Chpt. 4).

### b. Data Limitations of the Model

Data used to formulate input-output coefficients for the various cropping activities in this hypothetical model are only realistic for the soil types specified and climatic conditions assumed. They reflect to a large extent the author's experience as a field agronomist with the crops concerned in Malaysia and Indonesia.

Data on fixed and operational cost was obtained from a 1988 survey published by the Malaysian Estate Owners Association as well as from other sources. Commodity Price data was obtained from the World Bank's annual commodity review report for 1989.

Being a hypothetical model designed for wide applicability, capital availability and fixed and variable consumption requirements were somewhat arbitrarily specified in the model to some 'realistic' figure.

The various types of land resources available was similarly arbitrarily set at 100 Ha for each soil type so as to be able to look at the percentage of each soil resource that enters the optimal plan and the crops they are to be planted with.

Chapter 9

CONCLUSION

The model constructed in this study to allocate land to rubber, oil palm and cocoa has shown to be capable of generating profit maximizing planting plans for plantation managers by answering the crop-land allocation question of "what crops and on which soil type to plant."

The results obtained provide detailed planting plans with respect to the amount of a particular soil type that should be allocated to a crop and the year in which the planting(s) should be carried out. In addition, the amount of labour, fertilizer and capital required in any of the three years within the horizon is generated, as is the amount of crop produced and sold. Also, annual income and expenses are automatically allocated to the various tax-brackets in such a manner as to minimize cash lost through taxation to provide a picture of the cash flow situation.

By making multiple optimization runs, the sensitivity of the optimal plan to changes in the various parameters can also be examined. This ability makes this a flexible tool to study resource allocation decisions of the type described. The ability to quickly vary parameters and to obtain solutions enables the analyst to determine within a short time, the boundaries of the solution set for the particular problem analysed. It is not necessarily the optimal solution that is of greatest importance, but rather the ability of delineating the boundaries within which the decision maker can make rational decisions.

Possible Uses of the Model

Although intertemporal programming requires the collection and formulation of a considerable amount of data into a model framework, once a model has been constructed, much technical data (such as input-output coefficients) would have been collected and may be drawn upon when programming similar holdings in the future (provided that such input-output data is modified in response to any technological advances, input or output price changes etc.).

It is important however, that the person (re)formulating or modifying the programming model has a sound knowledge of agronomic techniques in the geographical locality of the study.

It has been the authors intention in carrying out this study to develop a very broad and widely applicable mathematical framework for making land-use decisions with respect to the three perennial crops of economic importance in Malaysia and Indonesia. The model was therefore designed for a hypothetical plantation consisting of diverse soil/terrain types, so that it can be easily used (with minimal modifications) to complement soil survey studies in arriving at an optimal land-use plan for other holdings involved in similar cropping activities.

In addition, with some modifications, the model could also be used for:

- studying the optimal investment strategy when the three perennial crops considered are integrated with other cropping (including annual cropping) and forestry activities. Since the cultivation of fruit trees and plantation forestry is increasing in popularity in Malaysia, they would be prime candidates for inclusion into an expanded model.
- studying the effect of the use of improved latex harvesting technology (introduced in 1989/90) on Rubber trees on the optimal land allocation plan. A study of this nature is expected to provide interesting results as the technology has increased rubber yields in commercial trials by up to three to five times current yields !
- carrying out an analysis of the stability of the optimal plans in the face of expected changes in commodity and input resource market conditions. Alternatively, Supply and Demand functions could be econometrically estimated for inclusion into the model so that commodity and /or factor input prices can be forecasted endogenously.
- studying the effects of renting land on the organization of perennial crop production.

A further possible use of the model developed in this study could be to formulate Regionally Aggregated Linear Programming Models for a particular commodity or group of commodities. For example, the aggregate ('normative') supply function for some crop(s) in a specified region can be determined, indicating the quantities of the crop(s) which would or should be supplied at their various prices.

All the above applications of the developed model in the planning / analytical process are however subject to the fallacy of composition that is characteristic to linear production functions and the simplifying assumptions made. Linear programming is a powerful decision making tool, but by no means perfect, especially when used in an intertemporal context.

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## **A P P E N D I C E S**

1. Soil Classification Table
2. -Field Costs, Projected Commodity Prices  
and Crop Yield Profiles.  
-Sample Asset Value Computation (by Crop).
3. Plantation Labour & Capital Requirements.
4. The Matrix of the Formulated Model.
5. Computed Output of the formulated matrix.

APPENDIX 1  
SOIL CLASSIFICATION TABLE

Geology of Parent Material	Soil Series	Physiography Terrain (ie Slope)	Colour	Texture	Structure	Consistency	Internal Drainage Type	Nutrient Status
<b>IGNEOUS ROCK</b>								
Granite	Rengam	SL	BY - YB	S	SBK	Friable	Well Drained	v. poor
Granodiorite	Jerangau	ST	B - YR	S	SBK	Friable - Firm	Med. to Rapid	v.v. poor
Basalt	Kuantan	ST	RB	C	SBK	V. Friable	Med. to Rapid	v. poor
Andesite	Segamat	ST	YR - R	C	SBK	V. Friable	Med. to Rapid	poor
Rhyolites & Volcanic	Kulai	ST	YB - B	C	ABK	Firm	Mod. Well Drained	
Dacite	Yong Peng	ST	B - YR	C	SBK / ABK	Friable	Well Drained	
<b>METAMORPHIC ROCK</b>								
Schist	Seramban	ST	RY - YR	SC	SBK	Friable - Firm	Mod. Well Drained	
<b>SEDIMENTARY ROCK</b>								
<b>- Argillaceous</b>								
Shale	Prang	ST	YR	C	SBK	V. Friable	Well Drained	
Shale	Munchong	SL	YB - B	C	SBK	Friable - Firm	Mod. Well Drained	marginal
Shale	Durian	ST	B - YR	C	ABK	Firm - V.Firm	Mod. Well Drained	
Shale	Batu Anam	SL	Y - G	C	ABK	Firm - V.Firm	Imperfectly Drained	
Shale	Gajah Mati	SL	B	C	SBK	V. Friable	Well Drained	
Shale (lateritic)	Tauy	ST	YR - B	SC	SBK	Friable	Mod. Well Drained	
Shale (lateritic)	Malacca	FL	BY - R	SC	SBK	V. Friable	Well Drained	
Quartzite / Shale	Bungor	ST	YB - B	SC	SBK	Friable - Firm	Well Drained	
<b>- Arenaceous</b>								
Sandstone	Serdang	ST	B - BY	S	SBK	Friable	Excessively Drained	infertile
Quartzite & Sandstone	Kedah	ST	B	SC	SBK	Friable - Firm	Well Drained	
<b>ALLUVIAL</b>								
<b>- Older Alluviums</b>								
	Harimau	SL	YB - BY	SC	SBK	Friable - Firm	Mod. Well Drained	
	Ulu Tiram	SL	YB	S	SBK	Friable - Firm	Mod. Well Drained	
	Tampoi	SL	RY - YR	S	SBK	Friable - Firm	Mod. Well Drained	
<b>- Sub-Recent Alluviums</b>								
	Klau	ST	YB - BY	SC	SBK	Friable - Firm	Mod. Well Drained	
	Holyrood	SL	YB	SC	SBK	V. Friable	Excessively Drained	
	Sogomena	FL	G - Wh	C	ABK	Firm	Imperfectly Drained	
	Sitiawan	FL	Y	C	ABK	Firm	Imperfectly Drained	
<b>- Recent Alluviums</b>								
	Sg. Buloh	FL	B - YB - Y	S	SBK	Loose - V.Friable	Excessively Drained	
<b>- Marine Alluviums</b>								
	Briah	FL	B - BG	C	SBK	Friable - Firm	Poorly Drained	n. fertile
	Selangor	FL	GB	C	ABK	Friable - Firm	Imperfectly Drained	v. fertile
	Linau	FL	B	C / Peat	SBK	Friable - Firm	Poorly Drained	
<b>ORGANIC</b>								
- Peat		FL	B - B1	Peat			V. Poorly Drained	
- Muck		FL	B1	Muck			V. Poorly Drained	

KEY:

====

Terrain

-----  
FL = Flat  
SL = Sloping  
ST = Steep

Texture

-----  
S = Sandy  
SC = Sandy-Clay  
C = Clayey

Colour

-----  
Y = Yellow  
R = Red  
B = Brown  
G = Grey  
Bl = Black  
Wh = White  
YB = Yellowish Brown

Structure

-----  
SBK = Sub-Angular Blocky  
ABK = Angular Blocky

Note:

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The input-output coefficients of the various cropping activities used in the model was based on the soil type's slope and textural characteristics (as these soil variables were considered most important in deciding on crop-land suitability).

Thus in the model, each combination of crop-slope-texture comprised a cropping activity.

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APPENDIX 2

FIELD EXPENSES, COMMODITY PRICES  
AND  
CROP-LAND YIELD PROFILES

1. FIELD EXPENSES (M\$/Ha)

A. IMMATURE AREA (All Crops)

	- Age -			
	1	2	3	4
Field Maintenance	400	240	150	100

Note: Year 1 costs include clearing, land preparation and planting. All costs include weeding, pest and disease control, fertilization as well as road and drain maintenance.

B. MATURE AREA

RUBBER

ITEM	Cost / Ha (M\$)
Weeding	38.11
Pest & Disease	32.27
Manuring	150.79
Tapping & Collection	1,461.05
Transport	85.22
Roads & Bridges	2.65
Processing (@ \$ 0.20 / kg)	300.00
> TOTAL:	2,070.09

## OIL PALM

ITEM	Cost / Ha (M\$)
Weeding	120.00
Pest & Disease	30.71
Manuring	370.81
Harvesting & Collection	294.02
Transport	296.67
Roads & Bridges	28.30
Drains & Watergates	22.68
Processing (@ \$ 25 / ton)	550.00
> TOTAL:	1,713.19

## COCOA

ITEM	Cost / Ha (M\$)
Weeding	48.50
Pest & Disease	113.47
Manuring	526.09
Shade Upkeep	28.98
Pruning & Sanitation	80.16
Harvesting & Collection	458.78
Transport	0.00
Roads & Bridges	34.69
Processing	235.17
> TOTAL:	1,525.84

### NOTE:

Only Field & Processing Costs are included here.

The above figures were obtained from the management of a large and well managed plantation company in Malaysia involved in the cultivation of all three perennial crops. Comparison of these figures with that of other plantations indicate it to be a reasonably good representative of the costs involved in cultivating these crops commercially in Malaysia. However, some minor adjustments were still required to get more realistic figures as shown by the Malaysian Estate Owners Association (MEDA) survey (1988).

## 2. PRICE PROJECTIONS

The Prices used in the study were those observed upto 1989, and as projected by the FAO for 1990 upto 2000.

YEAR >	1988	1989	1990	1995	2000
<b>Rubber</b>					
			- M\$ / kg -		
-Dry Rubber	1.93	1.45	2.25	2.25	2.25
<b>Oil Palm</b>					
			- M\$ / ton -		
-FFB	200.00	150.00	129.50	167.45	158.95
-Palm oil	1000.00	750.00	647.40	837.20	769.60
-Kernel oil	650.00	487.50	449.80	533.00	465.40
<b>Cocoa</b>					
			- M\$ / kg -		
-Dry Bean	2.35	2.93	1.79	1.98	1.94

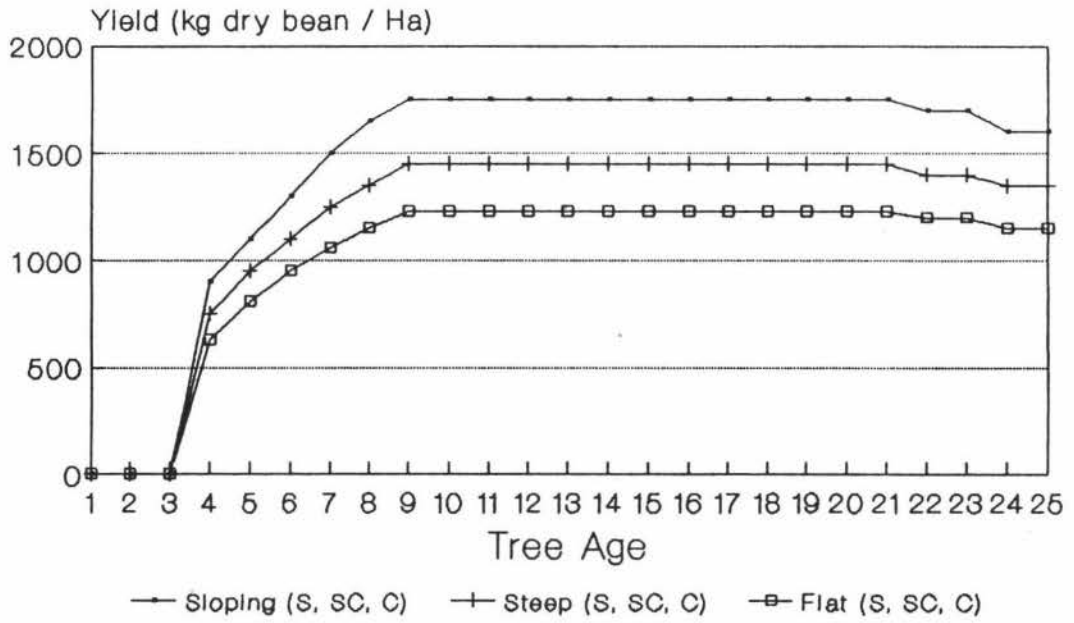
Source: World Bank - Revision of Commodity Price Forecasts and Quarterly Review of Commodity Markets. (Sept 1989).

## 3. CROP YIELD PROFILES

The Yield profiles of the three perennial crops for the various land-crop classes is graphed below.



# Cocoa Yields (Stand/Ha = 1000)



Source: ARAB.

### Asset Value Computations

-Financial Returns from OIL PALM Fields-

Cash Flow for 25 Years.

ENDOGENOUS VARIABLES (for Sensitivity Analysis):

<b>PRODUCTION</b>	<b>FINANCE</b> (Table Mortgage)	<b>CAP.COST / DEPR. / TAX</b>	<b>FIELD DETAILS</b>
Equity= 0	InflRate= 0.04	Fld: High Yield	SoilType:Mineral
TotLoan= 0	Nom IntRate= 0.05	Haz: 1	Texture: SC
IntRate= 0.15	Real IntRate= 0.009615		Terrain: Flat
Annuity= 0		PltYr:	RF (mm): 2200
25 years.	Ann.Depr= 0	CurYr:	RD(days): 100
	Income TaxRate= 0.35	CurAge:	

RESULTS :

TotInt= 0	NetCashFlow= 27680.20
TotPrinc= 0	[AfterTax]
IRR = 1.137749	
NPV = 17640.4	
AV = 24546.54	

SPREADSHEET:

PalmAge	Year 1991=1	Equity	FFB Yield tons/Ha	FFB TotProd tons	Oil Extract Rate	Oil TotProd tons	Oil Price \$/ton	Oil Rev \$	Kernel Extract Rate	Kernel TotProd tons	Kernel Price \$/ton	Kernel Rev \$	TOTAL REV	TOTAL EXP	Int	Princ	Outstand Princ.	Taxable Income	Tax	CashFlow AfterTax	No. of Periods/Yr = 1		
																					PV	Rshort	
0	0	0	0	0	0.1955	0	647.4	0	0.055	0	449.8	0	0	400	0	0	0	-400	-140	-260	0	0	
1	0	0	0	0	0.1955	0	647.4	0	0.055	0	449.8	0	0	240	0	0	0	-240	-84	-156	0	-247.619	
2	0	0	0	0	0.1955	0	647.4	0	0.055	0	449.8	0	0	150	0	0	0	508.638	178.0233	330.6147	0	285.5974	
3	0	4.5	4.5	0.1955	0.87975	750	659.8125	0.055	0.2475	449.8	111.3255	658.638	150	0	0	0	0	2045.46	715.911	1329.549	1266.237	1093.823	
4	0	15	15	0.1955	2.9325	750	2199.375	0.055	0.825	449.8	371.085	2195.46	150	0	0	0	0	1507.008	527.4528	979.5552	888.4854	767.5071	
5	0	22	22	0.1955	4.301	750	3225.75	0.055	1.21	449.8	544.258	3220.008	1713	0	0	0	0	2822.665	987.9328	1834.732	1584.911	1369.105	
6	0	27	27	0.1955	5.2785	837.2	4419.16	0.055	1.485	533	791.505	4535.665	1713	0	0	0	0	2990.653	1046.728	1943.924	1599.271	1381.511	
7	0	28	28	0.1955	5.474	837.2	4582.833	0.055	1.54	533	820.82	4703.653	1713	0	0	0	0	2822.665	987.9328	1834.732	1437.561	1241.819	
8	0	27	27	0.1955	5.2785	837.2	4419.16	0.055	1.485	533	791.505	4535.665	1713	0	0	0	0	2738.671	958.535	1780.136	1328.365	1147.492	
9	0	26.5	26.5	0.1955	5.18075	837.2	4337.324	0.055	1.4575	533	776.8475	4451.671	1713	0	0	0	0	2654.678	929.1372	1725.54	1226.309	1059.332	
10	0	26	26	0.1955	5.083	837.2	4255.488	0.055	1.43	533	762.19	4367.678	1713	0	0	0	0	2138.872	748.6052	1390.267	940.9872	812.8602	
11	0	25.5	25.5	0.1955	4.98525	769.6	3836.648	0.055	1.4025	465.4	652.7235	3851.872	1713	0	0	0	0	2063.345	722.1707	1341.174	864.5329	746.816	
12	0	25	25	0.1955	4.8875	769.6	3761.42	0.055	1.375	465.4	639.925	3776.345	1713	0	0	0	0	1987.818	695.7363	1292.082	793.2261	685.2185	
13	0	24.5	24.5	0.1955	4.78975	769.6	3686.192	0.055	1.3475	465.4	627.1265	3700.818	1713	0	0	0	0	1912.291	669.3019	1242.989	726.7501	627.794	
14	0	24	24	0.1955	4.692	769.6	3610.963	0.055	1.32	465.4	614.328	3625.291	1713	0	0	0	0	1836.764	642.8675	1193.897	664.8064	574.2848	
15	0	23.5	23.5	0.1955	4.59425	769.6	3535.735	0.055	1.2925	465.4	601.5295	3549.764	1713	0	0	0	0	1761.237	616.4331	1144.804	607.1142	524.448	
16	0	23	23	0.1955	4.4965	769.6	3460.506	0.055	1.265	465.4	588.731	3474.237	1713	0	0	0	0	1761.237	616.4331	1144.804	578.204	499.4743	
17	0	23	23	0.1955	4.4965	769.6	3460.506	0.055	1.265	465.4	588.731	3474.237	1713	0	0	0	0	1610.184	563.5643	1046.619	479.4684	414.1828	
18	0	22	22	0.1955	4.301	769.6	3310.05	0.055	1.21	465.4	563.134	3323.184	1713	0	0	0	0	1610.184	563.5643	1046.619	456.6365	394.4598	
19	0	22	22	0.1955	4.301	769.6	3310.05	0.055	1.21	465.4	563.134	3323.184	1713	0	0	0	0	1459.13	510.6954	948.4344	394.0941	340.4333	
20	0	21	21	0.1955	4.1055	769.6	3159.593	0.055	1.155	465.4	537.537	3172.13	1713	0	0	0	0	1308.076	457.8266	850.2494	336.4726	290.6576	
21	0	20	20	0.1955	3.91	769.6	3009.136	0.055	1.1	465.4	511.94	3021.076	1713	0	0	0	0	1308.076	457.8266	850.2494	320.4501	276.8168	
22	0	20	20	0.1955	3.91	769.6	3009.136	0.055	1.1	465.4	511.94	3021.076	1713	0	0	0	0	1308.076	457.8266	850.2494	305.1905	263.635	
23	0	20	20	0.1955	3.91	769.6	3009.136	0.055	1.1	465.4	511.94	3021.076	1713	0	0	0	0	1308.076	457.8266	850.2494	290.6576	251.081	
24	0	20	20	0.1955	3.91	769.6	3009.136	0.055	1.1	465.4	511.94	3021.076	1713	0	0	0	0	1308.076	457.8266	850.2494	290.6576	251.081	
25	0	20	20	0.1955	3.91	769.6	3009.136	0.055	1.1	465.4	511.94	3021.076	1713	0	0	0	0	1308.076	457.8266	850.2494	290.6576	251.081	
<b>Totals:</b>			512.5	512.5		100.1937	78727.61			28.1875	13582.93	36913	0	0	0	0	0	42585.04	14904.76	27680.28	17640.4	6906.139	24546.54

-Financial Returns from COCOA Fields-

Cash Flow for 25 Years.

ENDOGENOUS VARIABLES (for Sensitivity Analysis):

PRODUCTION		FINANCE (Table Mortgage)		CAP.COST / DEPR. / TAX		FIELD DETAILS			
Area(Ha)=	1	Equity=	0	InflRate=	0.04	Fld:	High Yield	SoilType:	Mineral
		TotLoan=	0	Nom IntRate=	0.05	Ha:	1	Texture:	SC
		IntRate=	0.15	Real IntRate=	0.009615	Stand/Ha:	642	Terrain:	S1
		Annuity=	0			PltYr:		RF (mm):	2100
		25 years.		Ann.Depr=	0	CurYr:		RD(days):	100
				Income TaxRate=	0.35	CurAge:			

RESULTS :

TotInt=	0	NetCashFlow=	39564.85
TotPrinc=	0	[AfterTax]	
		IRR =	0.605603
		NPV =	21561
		AV =	32159.8

SPREADSHEET:

TreeAge	Year	Equity	Prod/Ha [Yield]	TotProd	Price	Rev	Exp	Int	Princ	Outstand Princ.	Taxable Income	Tax	CashFlow AfterTax	PV 0.05	Amort	
0		0	0							0			0			
1		0	0	0	1.79	0	400	0	0	0	-400	-140	-260	0	-260	
2		0	0	0	1.79	0	240	0	0	0	-240	-84	-156	0	-156	
3		0	0	0	1.79	0	150	0	0	0	-150	-52.5	-97.5	0	-97.5	
4		0	600	600	1.79	1074	150	0	0	0	924	323.4	600.6	572	600.6	
5		0	900	900	1.79	1611	1525	0	0	0	86	30.1	55.9	50.70295	55.9	
6		0	1200	1200	1.98	2376	1525	0	0	0	851	297.85	553.15	477.8318	526.8095	
7		0	1500	1500	1.98	2970	1525	0	0	0	1445	505.75	939.25	772.7233	851.9274	
8		0	1600	1600	1.98	3168	1525	0	0	0	1643	575.05	1067.95	836.7668	922.5354	
9		0	1750	1750	1.98	3465	1525	0	0	0	1940	679	1261	940.9776	1037.428	
10		0	1750	1750	1.98	3465	1525	0	0	0	1940	679	1261	896.1692	988.0265	
11		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1592.603	1755.845	
12		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1516.765	1672.233	
13		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1444.538	1592.603	
14		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1375.75	1516.765	
15		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1310.238	1444.538	
16		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1247.846	1375.75	
17		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1188.425	1310.238	
18		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1131.833	1247.846	
19		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1077.936	1188.425	
20		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	1026.606	1131.833	
21		0	1750	1750	2.94	5145	1525	0	0	0	3620	1267	2353	977.7201	1077.936	
22		0	1700	1700	2.94	4998	1525	0	0	0	3473	1215.55	2257.45	893.3496	984.918	
23		0	1650	1650	2.94	4851	1525	0	0	0	3326	1164.1	2161.9	814.7974	898.3141	
24		0	1600	1600	2.94	4704	1525	0	0	0	3179	1112.65	2066.35	741.7005	817.7249	
25		0	1550	1550	2.94	4557	1525	0	0	0	3032	1061.2	1970.8	673.7177	742.7738	
Totals:			35050	35050		93834	32965	0	0		60869	21304.15	39564.85	21561	10598.81	32159.8

-Financial Returns from RUBBER Fields-

Cash Flow for 25 Years.

ENDOGENOUS VARIABLES (for Sensitivity Analysis):

PRODUCTION		FINANCE (Table Mortgage)		CAP.COST / DEPR. / TAX		FIELD DETAILS			
Area(Ha)=	1	Equity=	0	InflRate=	0.04	Fld:	High Yield	SoilType:	Mineral
		TotLoan=	0	Nom IntRate=	0.05	Ha:	1	Texture:	S
		IntRate=	0.15	Real IntRate=	0.009615	Stand/Ha:	400	Terrain:	St
		Annuity=	0			PltYr:		RF (mm):	2200
		25 years.		Ann.Depr=	0	CurYr:		RD (days)	100
				Income TaxRate=	0.35	CurAge:			
						TapSys:	Normal		
						Panel:			

RESULTS :

TotInt=	0	NetCashFlow=	24147.5
TotPrinc=	0	[AfterTax]	
		IRR =	0.444726
		NPV =	13976.77
		AssetV & AV =	19270.05

SPREADSHEET:

TreeAge	Year	Equity	Prod/Ha [Yield]	TotProd kg	Price	Rev	Exp	Int	Princ	Outstand Princ.	Taxable Income	Tax	CashFlow AfterTax	PV 0.05	Amort	
0	0	0	0							0			0	0		
1	0	0	0	0	2.25	0	400	0	0	0	-400	-140	-260	0	-247.619	
2	0	0	0	0	2.25	0	240	0	0	0	-240	-84	-156	0	-141.497	
3	0	0	0	0	2.25	0	150	0	0	0	-150	-52.5	-97.5	0	-84.2242	
4	0	0	0	0	2.25	0	100	0	0	0	-100	-35	-65	-61.9048	-53.4757	
5	0	0	0	0	2.25	0	100	0	0	0	-100	-35	-65	-58.9569	-50.9292	
6	0	0	1300	1300	2.25	2665	2070	0	0	0	595	208.25	386.75	334.0892	288.5988	
7	0	0	1500	1500	2.25	3075	2070	0	0	0	1005	351.75	653.25	537.4304	464.2526	
8	0	0	1800	1800	2.25	3690	2070	0	0	0	1620	567	1053	825.053	712.7118	
9	0	0	2000	2000	2.25	4100	2070	0	0	0	2030	710.5	1319.5	984.6312	850.5615	
10	0	0	2100	2100	2.25	4305	2070	0	0	0	2235	782.25	1452.75	1032.442	891.8625	
11	0	0	2200	2200	2.25	4510	2070	0	0	0	2440	854	1586	1073.467	927.3013	
12	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	1108.244	957.3427	
13	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	1055.47	911.755	
14	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	1005.21	868.3381	
15	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	957.3427	826.9886	
16	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	911.755	787.6082	
17	0	0	2300	2300	2.25	4715	2070	0	0	0	2645	925.75	1719.25	868.3381	750.1031	
18	0	0	2200	2200	2.25	4510	2070	0	0	0	2440	854	1586	762.8931	659.0158	
19	0	0	2100	2100	2.25	4305	2070	0	0	0	2235	782.25	1452.75	665.5215	574.9025	
20	0	0	2000	2000	2.25	4100	2070	0	0	0	2030	710.5	1319.5	575.6935	497.3057	
21	0	0	1800	1800	2.25	3690	2070	0	0	0	1620	567	1053	437.5432	377.9663	
22	0	0	1500	1500	2.25	3075	2070	0	0	0	1005	351.75	653.25	258.5132	223.3134	
23	0	0	1500	1500	2.25	3075	2070	0	0	0	1005	351.75	653.25	246.203	212.6794	
24	0	0	1500	1500	2.25	3075	2070	0	0	0	1005	351.75	653.25	234.4791	202.5519	
25	0	0	1500	1500	2.25	3075	2070	0	0	0	1005	351.75	653.25	223.3134	192.9065	
Totals:			38800	38800		79540	42390	0	0		37150	13002.5	24147.5	13976.77	5293.282	19270.05

APPENDIX 3

PLANTATION LABOUR AND CAPITAL REQUIREMENTS

1. PLANTATION LABOUR REQUIREMENTS

A. Immature (Rubber, Oil Palm & Cocoa)

ITEM	- AGE -			
	1	2	3	4
	(Man-Days / Ha / Year)			
Nursery	0.5			
Clearing & Land Prep.	1.6			
Roads & Drains	1.0	0.3	0.2	0.2
Lining & Staking	1.2			
Holing & Planting	0.6	0.1	0.05	
Field Maintenance				
Weed Control	0.4	2.0	1.0	0.3
Pest & Disease		0.7	0.6	0.7
Fertilizer		0.2	0.2	0.2
Pruning & Shaping		0.1	0.4	0.6
for Cocoa fields only:				
Shade Planting	0.2			
Shade Maintenance	0.9	0.4	0.3	0.1
- Total:		(Man Days per Ha)		
Rubber:	4.8	3.4	2.6	2.0
Oil Palm:	4.6	2.9	2.3	1.8
Cocoa:	5.9	4.4	3.2	2.4
- Total:		(Man Year per Ha)		
Rubber:	0.0165	0.0117	0.0092	0.0069
Oil Palm:	0.0158	0.0100	0.0083	0.0062
Cocoa:	0.0200	0.0150	0.0110	0.0083
- Total:		(Ha / worker / year)		
Rubber:	60	85	108	145
Oil Palm:	63	100	125	162
Cocoa:	50	67	90	120

Cost/Ha - M\$

- (M'sia)

Rubber:	48	34	26	20
Oil Palm:	46	29	23	18
Cocoa:	59	44	32	24

- (I'sia)

Rubber:	24	17	13	10
Oil Palm:	23	15	11	9
Cocoa:	30	22	16	12

**B. Mature (Rubber, Oil Palm & Cocoa)**

- Age 5 to 30 -

	Rubber	Oil Palm	Cocoa
	(Man-Days / Ha / Year)		
Field Maintenance	35	49	49 - 69
Harvesting	80 / 60	22 - 33	28
Pruning		4.4	4.0
- Total (Man Days per Ha):	110	81	62 - 82
- Total (Man Year per Ha):	0.38	0.28	0.25
(Ha / worker / year):	2.65	3.60	4.70-3.55
Cost/Ha - M\$ (M'sia)	1100	810	720-1230
(I'sia)	550	405	360-410

Man-Day Wage Rates

Malaysia: M\$ 10  
 Indonesia: M\$ 5 (Rp 3250)

Man-Days per Year = 291

**NOTE:** Field Maintenance includes Weeding, Pest & Disease control, Fertilization, and Road & Drain maintenance costs. Holing and Planting includes starter fertilizer application.

## 2. PLANTATION CAPITAL REQUIREMENTS

(M\$ / Ha / year)

ITEM	Rubber	Oil Palm	Cocoa
<u>Immature</u>			
Fertilizer	50	200	200
Herbicides	50	50	50
Pesticides	10	-	30-60
<u>Mature</u>			
Fertilizer	85	300	300
Herbicides	-	-	-
Pesticides	30-60	-	120

### AVERAGE CROP FERTILIZER REQUIREMENTS

(tons/Ha)

	Rubber	Oil Palm	Cocoa
Immature	0.14	0.66	0.66
Mature	0.25	0.99	0.99

NOTE: Average Fertilizer Cost = M\$ 300 / ton.

#### Sources:

Rubber: Rubber Owners Manual, Rubber Research Institute of Malaysia (1985).  
 Oil Palm: Hartley, C.W.S. The Oil Palm. Second Edition Longman (1977).  
 Cocoa: Wood, G.A.R. and Lass, R.A. Cocoa. Fourth Edition Longman (1985).

APPENDIX 4

MATRIX

CROP - LAND ALLOCATION MODEL

GULP 4.2 (C) Copyright 1988 Optimal Software

Problem: TLP R=5%

User: A.Guha

ID: CLAM

Page 1

	#	RHS	#	RUFS1	RUFSC1	RUFC1	RUFF1	RUSLS1
>ObjFn-MAX	N							
OpCashBal1	E	1000000.0						
TaxInc1	E							
TaxDed1	E	100000.00						
Exp1	E							
TaxLim11	L	12000.00						
TaxLim12	L	12000.00						
BorrLim1	L	500000.00						
ClCashBal1	E							
Consp1	G	10000.00						
RuFert1	L		0.14	0.14	0.14	0.14	0.14	
OPFert1	L							
CoFert1	L							
RuLab1	L		0.02	0.02	0.02	0.02	0.02	
OPLab1	L							
CoLab1	L							
RuCap1	L		70.00	70.00	70.00	70.00	70.00	
OPCap1	L							
CoCap1	L							
RuYield1	G							
OPYield1	G							
CoYield1	G							
OPCashBal2	E							
TaxInc2	E							
TaxDed2	E	100000.00						
Exp2	E							
TaxLim21	L	12000.00						
TaxLim22	L	12000.00						
BorrLim2	L	500000.00						
ClCashBal2	E							
Consp2	G	10000.00						
RuFert2	L		0.14	0.14	0.14	0.14	0.14	
OPFert2	L							
CoFert2	L							
RuLab2	L		0.01	0.01	0.01	0.01	0.01	
OPLab2	L							
CoLab2	L							
RuCap2	L		70.00	70.00	70.00	70.00	70.00	
OPCap2	L							
CoCap2	L							

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E					
TaxInc3	E					
TaxDed3	E	100000.00				
Exp3	E					
TaxLim31	L	12000.00				
TaxLim32	L	12000.00				
BorrLim3	L	500000.00				
ClCashBal3	E					
Consp3	G	10000.00				
TERM VAL	E	-10838.00	-9484.00	-8130.00		-14900.00
RuFert3	L	0.14	0.14	0.14	0.14	0.14
OPFert3	L					
CoFert3	L					
RuLab3	L	0.01	0.01	0.01	0.01	0.01
OPLab3	L					
CoLab3	L					
RuCap3	L	70.00	70.00	70.00	70.00	70.00
OPCap3	L					
CoCap3	L					
RuYield3	G					
OPYield3	G					
CoYield3	G					
F S	L	100.00	1.00			
F SC	L	100.00		1.00		
F C	L	100.00			1.00	
F P	L	100.00				1.00
SL S	L	100.00				
SL SC	L	100.00				1.00
SL C	L	100.00				
SL P	L					
ST S	L	100.00				
ST SC	L	100.00				
ST C	L	100.00				
ST P	L					

	RUSLSC1	RUSLC1	RUSLP1	RUSTS1	RUSTSC1	RUSTC1
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L	0.14	0.14	0.14	0.14	0.14
OPFert1	L					
CoFert1	L					
RuLab1	L	0.02	0.02	0.02	0.02	0.02
OPLab1	L					
CoLab1	L					
RuCap1	L	70.00	70.00	70.00	70.00	70.00
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L	0.14	0.14	0.14	0.14	0.14
OPFert2	L					
CoFert2	L					
RuLab2	L	0.01	0.01	0.01	0.01	0.01
OPLab2	L					
CoLab2	L					
RuCap2	L	70.00	70.00	70.00	70.00	70.00
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-13546.00	-12192.00	-19200.00	-19108.00	-19000.00	
RuFert3	L	0.14	0.14	0.14	0.14	0.14	0.14
OPFert3	L						
CoFert3	L						
RuLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
OPLab3	L						
CoLab3	L						
RuCap3	L	70.00	70.00	70.00	70.00	70.00	70.00
OPCap3	L						
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L	1.00					
SL C	L		1.00				
SL P	L			1.00			
ST S	L				1.00		
ST SC	L					1.00	
ST C	L						1.00
ST P	L						

	RUSTP1	OPFS1	OPFSC1	OPFC1	OPFP1	OPSL1
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L	0.14				
OPFert1	L		0.66	0.66	0.66	0.66
CoFert1	L					
RuLab1	L	0.02				
OPLab1	L		0.02	0.02	0.02	0.02
CoLab1	L					
RuCap1	L	70.00				
OPCap1	L		60.00	60.00	60.00	60.00
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L	0.14				
OPFert2	L		0.66	0.66	0.66	0.66
CoFert2	L					
RuLab2	L	0.01				
OPLab2	L		0.01	0.01	0.01	0.01
CoLab2	L					
RuCap2	L	70.00				
OPCap2	L		60.00	60.00	60.00	60.00
CoCap2	L					

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E					
TaxInc3	E					
TaxDed3	E					
Exp3	E					
TaxLim31	L					
TaxLim32	L					
BorrLim3	L					
ClCashBal3	E					
Consp3	G					
TERM VAL	E	-24000.00	-24500.00	-24750.00	-25000.00	-16487.00
RuFert3	L	0.14				
OPFert3	L		0.66	0.66	0.66	0.66
CoFert3	L					
RuLab3	L	0.01				
OPLab3	L		0.01	0.01	0.01	0.01
CoLab3	L					
RuCap3	L	70.00				
OPCap3	L		60.00	60.00	60.00	60.00
CoCap3	L					
RuYield3	G					
OPYield3	G		2.00	2.50	3.00	4.00
CoYield3	G					1.00
F S	L		1.00			
F SC	L			1.00		
F C	L				1.00	
F P	L					1.00
SL S	L					
SL SC	L					
SL C	L					
SL P	L					
ST S	L					
ST SC	L					
ST C	L					
ST P	L		1.00			

	OPSLSC1	OPSLC1	OPSLP1	OPSTS1	OPSTSC1	OPSTC1
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E						
Exp1 E						
TaxLim1 L						
TaxLim2 L						
BorrLim1 L						
ClCashBal1 E						
Consp1 G						
RuFert1 L						
OPFert1 L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert1 L						
RuLab1 L						
OPLab1 L	0.02	0.02	0.02	0.02	0.02	0.02
CoLab1 L						
RuCap1 L						
OPCap1 L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert2 L						
RuLab2 L						
OPLab2 L	0.01	0.01	0.01	0.01	0.01	0.01
CoLab2 L						
RuCap2 L						
OPCap2 L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap2 L						

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-17887.00	-19287.00	-12287.00	-13687.00	-15087.00	
RuFert3	L						
OPFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert3	L						
RuLab3	L						
OPLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
CoLab3	L						
RuCap3	L						
OPCap3	L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap3	L						
RuYield3	G						
OPYield3	G	1.50	2.00		0.50	1.00	1.50
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L	1.00					
SL C	L		1.00				
SL P	L			1.00			
ST S	L				1.00		
ST SC	L					1.00	
ST C	L						1.00
ST P	L						

	DPSTP1	COFS1	COFSC1	COFC1	COFP1	COSLS1
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L	0.66				
CoFert1	L	0.66	0.66	0.66	0.66	0.66
RuLab1	L					
OPLab1	L	0.02				
CoLab1	L	0.02	0.02	0.02	0.02	0.02
RuCap1	L					
OPCap1	L	60.00				
CoCap1	L	95.00	95.00	95.00	95.00	95.00
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L	0.66				
CoFert2	L	0.66	0.66	0.66	0.66	0.66
RuLab2	L					
OPLab2	L	0.01				
CoLab2	L	0.01	0.01	0.01	0.01	0.01
RuCap2	L					
OPCap2	L	60.00				
CoCap2	L	95.00	95.00	95.00	95.00	95.00

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E					
TaxInc3	E					
TaxDed3	E					
Exp3	E					
TaxLim31	L					
TaxLim32	L					
BorrLim3	L					
ClCashBal3	E					
Consp3	G					
TERM VAL	E	-23152.00	-21175.00	-22162.00		-28237.00
RuFert3	L					
OPFert3	L	0.66				
CoFert3	L		0.66	0.66	0.66	0.66
RuLab3	L					
OPLab3	L	0.01				
CoLab3	L		0.01	0.01	0.01	0.01
RuCap3	L					
OPCap3	L	60.00				
CoCap3	L		95.00	95.00	95.00	95.00
RuYield3	G					
OPYield3	G					
CoYield3	G					
F S	L		1.00			
F SC	L			1.00		
F C	L				1.00	
F P	L					1.00
SL S	L					1.00
SL SC	L					
SL C	L					
SL P	L					
ST S	L					
ST SC	L					
ST C	L					
ST P	L	1.00				

	COSLSC1	COSLC1	COSLP1	COSTS1	COSTSC1	COSTC1
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L	0.66	0.66	0.66	0.66	0.66
RuLab1	L					
OPLab1	L					
CoLab1	L	0.02	0.02	0.02	0.02	0.02
RuCap1	L					
OPCap1	L					
CoCap1	L	95.00	95.00	95.00	95.00	95.00
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L	0.66	0.66	0.66	0.66	0.66
RuLab2	L					
OPLab2	L					
CoLab2	L	0.01	0.01	0.01	0.01	0.01
RuCap2	L					
OPCap2	L					
CoCap2	L	95.00	95.00	95.00	95.00	95.00

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consm3	G						
TERM VAL	E	-32159.00	-30788.00		-15087.00	-17137.00	-16112.00
RuFert3	L						
OPFert3	L						
CoFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab3	L						
OPLab3	L						
CoLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
RuCap3	L						
OPCap3	L						
CoCap3	L	95.00	95.00	95.00	95.00	95.00	95.00
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L	1.00					
SL C	L		1.00				
SL P	L			1.00			
ST S	L				1.00		
ST SC	L					1.00	
ST C	L						1.00
ST P	L						

	COSTP1	SellRu1	SellOP1	SellCo1	RuFert1	OPFert1
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E	-2.25	-129.50	-1.79		
TaxDed1	E				-300.00	-300.00
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L				-1.00	
OPFert1	L					-1.00
CoFert1	L	0.66				
RuLab1	L					
OPLab1	L					
CoLab1	L	0.02				
RuCap1	L					
OPCap1	L					
CoCap1	L	95.00				
RuYield1	G	-1.00				
OPYield1	G		-1.00			
CoYield1	G			-1.00		
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L	0.66				
RuLab2	L					
OPLab2	L					
CoLab2	L	0.01				
RuCap2	L					
OPCap2	L					
CoCap2	L	95.00				

RuYield2	G	
OPYield2	G	
CoYield2	G	
OpCashBal3	E	
TaxInc3	E	
TaxDed3	E	
Exp3	E	
TaxLim31	L	
TaxLim32	L	
BorrLim3	L	
ClCashBal3	E	
Consp3	G	
TERM VAL	E	
RuFert3	L	
OPFert3	L	
CoFert3	L	0.66
RuLab3	L	
OPLab3	L	
CoLab3	L	0.01
RuCap3	L	
OPCap3	L	
CoCap3	L	95.00
RuYield3	G	
OPYield3	G	
CoYield3	G	
F S	L	
F SC	L	
F C	L	
F P	L	
SL S	L	
SL SC	L	
SL C	L	
SL P	L	
ST S	L	
ST SC	L	
ST C	L	
ST P	L	1.00

	CoFert1	RuLab1	OPLab1	CoLab1	RuCap1	OPCap1
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E	-300.00	-3000.00	-3000.00	-3000.00	-1.00	-1.00
Exp1 E						
TaxLim1 L						
TaxLim2 L						
BorrLim1 L						
ClCashBal1 E						
Consp1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L	-1.00					
RuLab1 L		-1.00				
OPLab1 L			-1.00			
CoLab1 L				-1.00		
RuCap1 L					-1.00	
OPCap1 L						-1.00
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L						
CoFert2 L						
RuLab2 L						
OPLab2 L						
CoLab2 L						
RuCap2 L						
OPCap2 L						
CoCap2 L						

RuYield2	G
OPYield2	G
CoYield2	G
OpCashBal3	E
TaxInc3	E
TaxDed3	E
Exp3	E
TaxLim31	L
TaxLim32	L
BorrLim3	L
ClCashBal3	E
Consp3	G
TERM VAL	E
RuFert3	L
OPFert3	L
CoFert3	L
RuLab3	L
OPLab3	L
CoLab3	L
RuCap3	L
OPCap3	L
CoCap3	L
RuYield3	G
OPYield3	G
CoYield3	G
F S	L
F SC	L
F G	L
F P	L
SL S	L
SL SC	L
SL C	L
SL P	L
ST S	L
ST SC	L
ST C	L
ST P	L

	CoCap1	TaxInc11	TaxInc12	TaxInc13	TaxDct1	TaxLoss1
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E		1.00	1.00	1.00	1.00	
TaxDed1 E	-1.00				1.00	1.00
Exp1 E					-1.00	-1.00
TaxLim11 L		1.00				
TaxLim12 L			1.00			
BorrLim1 L						
ClCashBal1 E		-1.00	-0.74	-0.65	-1.00	
Consp1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L						
RuLab1 L						
OPLab1 L						
CoLab1 L						
RuCap1 L						
OPCap1 L						
CoCap1 L	-1.00					
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						-1.00
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L						
CoFert2 L						
RuLab2 L						
OPLab2 L						
CoLab2 L						
RuCap2 L						
OPCap2 L						
CoCap2 L						

RuYield2	G
OPYield2	G
CoYield2	G
OpCashBal3	E
TaxInc3	E
TaxDed3	E
Exp3	E
TaxLim31	L
TaxLim32	L
BorrLim3	L
ClCashBal3	E
Consp3	G
TERM VAL	E
RuFert3	L
OPFert3	L
CoFert3	L
RuLab3	L
OPLab3	L
CoLab3	L
RuCap3	L
OPCap3	L
CoCap3	L
RuYield3	G
OPYield3	G
CoYield3	G
F S	L
F SC	L
F C	L
F P	L
SL S	L
SL SC	L
SL C	L
SL P	L
ST S	L
ST SC	L
ST C	L
ST P	L

	TotCost1	Borr1	Save1	Consp1	CshSur1	CshDef1
>ObjFn-MAX	N					
OpCashBal1	E	1.00	-1.00	1.00		
TaxInc1	E			-0.05		
TaxDed1	E		-0.05			
Exp1	E	1.00				
TaxLim11	L					
TaxLim12	L					
BorrLim1	L	1.00				
ClCashBal1	E	1.00	-1.00	1.00	1.00	-1.00
Consp1	G			1.00	-0.01	
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E				-1.00	1.00
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2 G  
OPYield2 G  
CoYield2 G  
OpCashBal3 E  
TaxInc3 E  
TaxDed3 E  
Exp3 E  
TaxLim31 L  
TaxLim32 L  
BorrLim3 L  
ClCashBal3 E  
Consm3 G  
TERM VAL E  
RuFert3 L  
OPFert3 L  
CoFert3 L  
RuLab3 L  
OPLab3 L  
CoLab3 L  
RuCap3 L  
OPCap3 L  
CoCap3 L  
RuYield3 G  
OPYield3 G  
CoYield3 G  
F S L  
F SC L  
F C L  
F P L  
SL S L  
SL SC L  
SL C L  
SL P L  
ST S L  
ST SC L  
ST C L  
ST P L

	RUFS2	RUFSC2	RUFC2	RUFF2	RUSLS2	RUSLSC2
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L	0.14	0.14	0.14	0.14	0.14
OPFert2	L					
CoFert2	L					
RuLab2	L	0.02	0.02	0.02	0.02	0.02
OPLab2	L					
CoLab2	L					
RuCap2	L	70.00	70.00	70.00	70.00	70.00
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-10238.00	-8884.00	-7530.00	-14300.00	-12946.00	
RuFert3	L	0.14	0.14	0.14	0.14	0.14	0.14
OPFert3	L						
CoFert3	L						
RuLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
OPLab3	L						
CoLab3	L						
RuCap3	L	70.00	70.00	70.00	70.00	70.00	70.00
OPCap3	L						
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L	1.00					
F SC	L		1.00				
F C	L			1.00			
F P	L				1.00		
SL S	L					1.00	
SL SC	L						1.00
SL C	L						
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	RUSLC2	RUSLP2	RUSTS2	RUSTSC2	RUSTC2	RUSTP2
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L	0.14	0.14	0.14	0.14	0.14
OPFert2	L					
CoFert2	L					
RuLab2	L	0.02	0.02	0.02	0.02	0.02
OPLab2	L					
CoLab2	L					
RuCap2	L	70.00	70.00	70.00	70.00	70.00
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-11592.00		-18520.00	-18500.00	-18480.00	
RuFert3	L	0.14	0.14	0.14	0.14	0.14	0.14
OPFert3	L						
CoFert3	L						
RuLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
OPLab3	L						
CoLab3	L						
RuCap3	L	70.00	70.00	70.00	70.00	70.00	70.00
OPCap3	L						
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L						
SL C	L	1.00					
SL P	L		1.00				
ST S	L			1.00			
ST SC	L				1.00		
ST C	L					1.00	
ST P	L						1.00

	OPFS2	OPFSC2	OPFC2	OPFP2	OPSL2	OPSLC2
>ObjFn-MAX	N					
OpCashBal1	E					
TaxIncl	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L	0.66	0.66	0.66	0.66	0.66
CoFert2	L					
RuLab2	L					
OPLab2	L	0.02	0.02	0.02	0.02	0.02
CoLab2	L					
RuCap2	L					
OPCap2	L	60.00	60.00	60.00	60.00	60.00
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-22087.00	-22687.00	-23000.00	-23200.00	-15487.00	-16887.00
RuFert3	L						
OPFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert3	L						
RuLab3	L						
OPLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
CoLab3	L						
RuCap3	L						
OPCap3	L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L	1.00					
F SC	L		1.00				
F C	L			1.00			
F P	L				1.00		
SL S	L					1.00	
SL SC	L						1.00
SL C	L						
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	DPSLC2	DPSLP2	DPSTS2	DPSTSC2	DPSTC2	DPSTP2
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E						
Exp1 E						
TaxLim11 L						
TaxLim12 L						
BorrLim1 L						
ClCashBal1 E						
Consp1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L						
RuLab1 L						
OPLab1 L						
CoLab1 L						
RuCap1 L						
OPCap1 L						
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert2 L						
RuLab2 L						
OPLab2 L	0.02	0.02	0.02	0.02	0.02	0.02
CoLab2 L						
RuCap2 L						
OPCap2 L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap2 L						

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-18287.00		-11287.00	-12687.00	-14087.00	
RuFert3	L						
OPFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert3	L						
RuLab3	L						
OPLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
CoLab3	L						
RuCap3	L						
OPCap3	L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L						
SL C	L	1.00					
SL P	L		1.00				
ST S	L			1.00			
ST SC	L				1.00		
ST C	L					1.00	
ST P	L						1.00

	COFS2	COFSC2	COFC2	COFP2	COSLS2	COSLSC2
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E						
Exp1 E						
TaxLim1 L						
TaxLim12 L						
BorrLim1 L						
ClCashBal1 E						
Consp1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L						
RuLab1 L						
OPLab1 L						
CoLab1 L						
RuCap1 L						
OPCap1 L						
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L						
CoFert2 L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab2 L						
OPLab2 L						
CoLab2 L	0.02	0.02	0.02	0.02	0.02	0.02
RuCap2 L						
OPCap2 L						
CoCap2 L	95.00	95.00	95.00	95.00	95.00	95.00

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-19452.00	-19485.00	-19462.00	-25537.00	-29587.00	
RuFert3	L						
OPFert3	L						
CoFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab3	L						
OPLab3	L						
CoLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
RuCap3	L						
OPCap3	L						
CoCap3	L	95.00	95.00	95.00	95.00	95.00	95.00
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L	1.00					
F SC	L		1.00				
F C	L			1.00			
F P	L				1.00		
SL S	L					1.00	
SL SC	L						1.00
SL C	L						
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	COSLC2	COSLP2	COSTS2	COSTSC2	COSTC2	COSTF2
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E						
Exp1 E						
TaxLim11 L						
TaxLim12 L						
BorrLim1 L						
ClCashBal1 E						
Consp1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L						
RuLab1 L						
OPLab1 L						
CoLab1 L						
RuCap1 L						
OPCap1 L						
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						
TaxInc2 E						
TaxDed2 E						
Exp2 E						
TaxLim21 L						
TaxLim22 L						
BorrLim2 L						
ClCashBal2 E						
Consp2 G						
RuFert2 L						
OPFert2 L						
CoFert2 L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab2 L						
OPLab2 L						
CoLab2 L	0.02	0.02	0.02	0.02	0.02	0.02
RuCap2 L						
OPCap2 L						
CoCap2 L	95.00	95.00	95.00	95.00	95.00	95.00

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consm3	G						
TERM VAL	E	-28305.00		-13387.00	-17437.00	-15412.00	
RuFert3	L						
OPFert3	L						
CoFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab3	L						
OPLab3	L						
CoLab3	L	0.01	0.01	0.01	0.01	0.01	0.01
RuCap3	L						
OPCap3	L						
CoCap3	L	95.00	95.00	95.00	95.00	95.00	95.00
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L						
SL C	L	1.00					
SL P	L		1.00				
ST S	L			1.00			
ST SC	L				1.00		
ST C	L					1.00	
ST P	L						1.00

	SellRu2	SellOP2	SellCo2	RuFert2	OPFert2	CoFert2
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E	-2.25	-129.50	-1.79		
TaxDed2	E			-300.00	-300.00	-300.00
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L			-1.00		
OPFert2	L				-1.00	
CoFert2	L					-1.00
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G	-1.00		
OPYield2	G		-1.00	
CoYield2	G			-1.00
OpCashBal3	E			
TaxInc3	E			
TaxDed3	E			
Exp3	E			
TaxLim31	L			
TaxLim32	L			
BorrLim3	L			
ClCashBal3	E			
Consp3	G			
TERM VAL	E			
RuFert3	L			
OPFert3	L			
CoFert3	L			
RuLab3	L			
OPLab3	L			
CoLab3	L			
RuCap3	L			
OPCap3	L			
CoCap3	L			
RuYield3	G			
OPYield3	G			
CoYield3	G			
F S	L			
F SC	L			
F C	L			
F P	L			
SL S	L			
SL SC	L			
SL C	L			
SL P	L			
ST S	L			
ST SC	L			
ST C	L			
ST P	L			

	RuLab2	OPLab2	CoLab2	RuCap2	OpCap2	CoCap2
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E	-3000.00	-3000.00	-3000.00	-1.00	-1.00
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L	-1.00				
OPLab2	L		-1.00			
CoLab2	L			-1.00		
RuCap2	L			-1.00		
OPCap2	L				-1.00	
CoCap2	L					-1.00

RuYield2	G
OPYield2	G
CoYield2	G
OpCashBal3	E
TaxInc3	E
TaxDed3	E
Exp3	E
TaxLim31	L
TaxLim32	L
BorrLim3	L
ClCashBal3	E
Consm3	G
TERM VAL	E
RuFert3	L
OPFert3	L
CoFert3	L
RuLab3	L
OPLab3	L
CoLab3	L
RuCap3	L
OPCap3	L
CoCap3	L
RuYield3	G
OPYield3	G
CoYield3	G
F S	L
F SC	L
F C	L
F P	L
SL S	L
SL SC	L
SL C	L
SL P	L
ST S	L
ST SC	L
ST C	L
ST P	L

	TaxInc21	TaxInc22	TaxInc23	TaxDct2	TaxLoss2	TotCost2
>ObjFn-MAX N						
OpCashBal1 E						
TaxInc1 E						
TaxDed1 E						
Exp1 E						
TaxLim1 L						
TaxLim2 L						
BorrLim1 L						
ClCashBal1 E						
Consm1 G						
RuFert1 L						
OPFert1 L						
CoFert1 L						
RuLab1 L						
OPLab1 L						
CoLab1 L						
RuCap1 L						
OPCap1 L						
CoCap1 L						
RuYield1 G						
OPYield1 G						
CoYield1 G						
OPCashBal2 E						1.00
TaxInc2 E	1.00	1.00	1.00	1.00		
TaxDed2 E				1.00	1.00	
Exp2 E				-1.00	-1.00	1.00
TaxLim21 L	1.00					
TaxLim22 L		1.00				
BorrLim2 L						
ClCashBal2 E	-1.00	-0.74	-0.65	-1.00		
Consm2 G						
RuFert2 L						
OPFert2 L						
CoFert2 L						
RuLab2 L						
OPLab2 L						
CoLab2 L						
RuCap2 L						
OPCap2 L						
CoCap2 L						

RuYield2 G  
 OPYield2 G  
 CoYield2 G  
 OpCashBal3 E  
 TaxInc3 E  
 TaxDed3 E  
 Exp3 E  
 TaxLim31 L  
 TaxLim32 L  
 BorrLim3 L  
 ClCashBal3 E  
 Consm3 G  
 TERM VAL E  
 RuFert3 L  
 OPFert3 L  
 CoFert3 L  
 RuLab3 L  
 OPLab3 L  
 CoLab3 L  
 RuCap3 L  
 OPCap3 L  
 CoCap3 L  
 RuYield3 G  
 OPYield3 G  
 CoYield3 G  
 F S L  
 F SC L  
 F C L  
 F P L  
 SL S L  
 SL SC L  
 SL C L  
 SL P L  
 ST S L  
 ST SC L  
 ST C L  
 ST P L

-1.00

	Borr2	Save2	Consm2	CshSur2	CshDef2	RUF53
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consm1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E	-1.00	1.00			
TaxInc2	E		-0.05			
TaxDed2	E	-0.05				
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L	1.00				
ClCashBal2	E	1.00	-1.00	1.00	1.00	-1.00
Consm2	G		1.00	-0.01		
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G		
OPYield2	G		
CoYield2	G		
OpCashBal3	E	-1.00	1.00
TaxInc3	E		
TaxDed3	E		
Exp3	E		
TaxLim31	L		
TaxLim32	L		
BorrLim3	L		
ClCashBal3	E		
Consp3	G		
TERM VAL	E		-9638.00
RuFert3	L		0.14
OPFert3	L		
CoFert3	L		
RuLab3	L		0.02
OPLab3	L		
CoLab3	L		
RuCap3	L		70.00
OPCap3	L		
CoCap3	L		
RuYield3	G		
OPYield3	G		
CoYield3	G		
F S	L		1.00
F SC	L		
F C	L		
F P	L		
SL S	L		
SL SC	L		
SL C	L		
SL P	L		
ST S	L		
ST SC	L		
ST C	L		
ST P	L		

	RUFSC3	RUFC3	RUFP3	RUSLS3	RUSLSC3	RUSLC3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consm3	G						
TERM VAL	E	-8289.00	-6300.00	-13700.00	-12346.00	-10992.00	
RuFert3	L	0.14	0.14	0.14	0.14	0.14	0.14
OPFert3	L						
CoFert3	L						
RuLab3	L	0.02	0.02	0.02	0.02	0.02	0.02
OPLab3	L						
CoLab3	L						
RuCap3	L	70.00	70.00	70.00	70.00	70.00	70.00
OPCap3	L						
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L	1.00					
F C	L		1.00				
F P	L			1.00			
SL S	L				1.00		
SL SC	L					1.00	
SL C	L						1.00
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	RUSLP3	RUSTS3	RUSTSC3	RUSTC3	RUSTP3	OPFS3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E					
TaxInc3	E					
TaxDed3	E					
Exp3	E					
TaxLim31	L					
TaxLim32	L					
BorrLim3	L					
ClCashBal3	E					
Consm3	G					
TERM VAL	E	-17920.00	-17900.00	-17880.00		-20087.00
RuFert3	L	0.14	0.14	0.14	0.14	
OPFert3	L					0.66
CoFert3	L					
RuLab3	L	0.02	0.02	0.02	0.02	
OPLab3	L					0.02
CoLab3	L					
RuCap3	L	70.00	70.00	70.00	70.00	
OPCap3	L					60.00
CoCap3	L					
RuYield3	G					
OPYield3	G					
CoYield3	G					
F S	L					1.00
F SC	L					
F C	L					
F P	L					
SL S	L					
SL SC	L					
SL C	L					
SL P	L	1.00				
ST S	L		1.00			
ST SC	L			1.00		
ST C	L				1.00	
ST P	L					1.00

	OPFSC3	OPFC3	OPFP3	OPSL3	OPSLC3	OPSLC3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-20687.00	-21000.00	-21200.00	-14487.00	-15887.00	-17287.00
RuFert3	L						
OPFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
CoFert3	L						
RuLab3	L						
OPLab3	L	0.02	0.02	0.02	0.02	0.02	0.02
CoLab3	L						
RuCap3	L						
OPCap3	L	60.00	60.00	60.00	60.00	60.00	60.00
CoCap3	L						
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L	1.00					
F C	L		1.00				
F P	L			1.00			
SL S	L				1.00		
SL SC	L					1.00	
SL C	L						1.00
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	OPSLP3	OPSTS3	OPSTSC3	OPSTC3	OPSTP3	COFS3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E					
TaxInc3	E					
TaxDed3	E					
Exp3	E					
TaxLim31	L					
TaxLim32	L					
BorrLim3	L					
ClCashBal3	E					
Consp3	G					
TERM VAL	E	-10287.00	-11687.00	-13087.00		-18780.00
RuFert3	L					
OPFert3	L	0.66	0.66	0.66	0.66	
CoFert3	L					0.66
RuLab3	L					
OPLab3	L	0.02	0.02	0.02	0.02	
CoLab3	L					0.02
RuCap3	L					
OPCap3	L	60.00	60.00	60.00	60.00	
CoCap3	L					95.00
RuYield3	G					
OPYield3	G					
CoYield3	G					
F S	L					1.00
F SC	L					
F C	L					
F P	L					
SL S	L					
SL SC	L					
SL C	L					
SL P	L	1.00				
ST S	L		1.00			
ST SC	L			1.00		
ST C	L				1.00	
ST P	L					1.00

	COFSC3	COFC3	COFP3	COSL3	COSL3C3	COSLC3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						
TaxDed3	E						
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consp3	G						
TERM VAL	E	-18812.00	-18800.00	-23437.00	-27117.00	-25862.00	
RuFert3	L						
OPFert3	L						
CoFert3	L	0.66	0.66	0.66	0.66	0.66	0.66
RuLab3	L						
OPLab3	L						
CoLab3	L	0.02	0.02	0.02	0.02	0.02	0.02
RuCap3	L						
OPCap3	L						
CoCap3	L	95.00	95.00	95.00	95.00	95.00	95.00
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L	1.00					
F C	L		1.00				
F P	L			1.00			
SL S	L				1.00		
SL SC	L					1.00	
SL C	L						1.00
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	COSLP3	COSTS3	COSTSC3	COSTC3	COSTP3	SellRu3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G									
OPYield2	G									
CoYield2	G									
OpCashBal3	E									
TaxInc3	E									-2.25
TaxDed3	E									
Exp3	E									
TaxLim31	L									
TaxLim32	L									
BorrLim3	L									
ClCashBal3	E									
Consp3	G									
TERM VAL	E	-13687.00	-17737.00	-15712.00						
RuFert3	L									
OPFert3	L									
CoFert3	L	0.66	0.66	0.66	0.66	0.66				
RuLab3	L									
OPLab3	L									
CoLab3	L	0.02	0.02	0.02	0.02	0.02				
RuCap3	L									
OPCap3	L									
CoCap3	L	95.00	95.00	95.00	95.00	95.00				
RuYield3	G									-1.00
OPYield3	G									
CoYield3	G									
F S	L									
F SC	L									
F C	L									
F P	L									
SL S	L									
SL SC	L									
SL C	L									
SL P	L	1.00								
ST S	L		1.00							
ST SC	L			1.00						
ST C	L				1.00					
ST P	L					1.00				

	SellOP3	SellCo3	RuFert3	OPFert3	CoFert3	RuLab3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxIncl	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E	-129.50	-1.79				
TaxDed3	E			-300.00	-300.00	-300.00	-3000.00
Exp3	E						
TaxLim31	L						
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						
Consm3	G						
TERM VAL	E						
RuFert3	L			-1.00			
OPFert3	L				-1.00		
CoFert3	L					-1.00	
RuLab3	L						-1.00
OPLab3	L						
CoLab3	L						
RuCap3	L						
OPCap3	L						
CoCap3	L						
RuYield3	G						
OPYield3	G	-1.00					
CoYield3	G		-1.00				
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L						
SL C	L						
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	OPLab3	CoLab3	RuCap3	OPCap3	CoCap3	TaxInc31
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G						
OPYield2	G						
CoYield2	G						
OpCashBal3	E						
TaxInc3	E						1.00
TaxDed3	E	-3000.00	-3000.00	-1.00	-1.00	-1.00	
Exp3	E						
TaxLim31	L						1.00
TaxLim32	L						
BorrLim3	L						
ClCashBal3	E						-1.00
Consp3	G						
TERM VAL	E						
RuFert3	L						
DPFert3	L						
CoFert3	L						
RuLab3	L						
DPLab3	L	-1.00					
CoLab3	L		-1.00				
RuCap3	L			-1.00			
OPCap3	L				-1.00		
CoCap3	L					-1.00	
RuYield3	G						
OPYield3	G						
CoYield3	G						
F S	L						
F SC	L						
F C	L						
F P	L						
SL S	L						
SL SC	L						
SL C	L						
SL P	L						
ST S	L						
ST SC	L						
ST C	L						
ST P	L						

	TaxInc32	TaxInc33	TaxDct3	TaxLoss3	TotCost3	Borr3
>ObjFn-MAX	N					
OpCashBal1	E					
TaxInc1	E					
TaxDed1	E					
Exp1	E					
TaxLim11	L					
TaxLim12	L					
BorrLim1	L					
ClCashBal1	E					
Consp1	G					
RuFert1	L					
OPFert1	L					
CoFert1	L					
RuLab1	L					
OPLab1	L					
CoLab1	L					
RuCap1	L					
OPCap1	L					
CoCap1	L					
RuYield1	G					
OPYield1	G					
CoYield1	G					
OPCashBal2	E					
TaxInc2	E					
TaxDed2	E					
Exp2	E					
TaxLim21	L					
TaxLim22	L					
BorrLim2	L					
ClCashBal2	E					
Consp2	G					
RuFert2	L					
OPFert2	L					
CoFert2	L					
RuLab2	L					
OPLab2	L					
CoLab2	L					
RuCap2	L					
OPCap2	L					
CoCap2	L					

RuYield2	G					
OPYield2	G					
CoYield2	G					
OpCashBal3	E				1.00	-1.00
TaxInc3	E	1.00	1.00	1.00		
TaxDed3	E			1.00	1.00	-0.05
Exp3	E			-1.00	-1.00	1.00
TaxLim31	L					
TaxLim32	L	1.00				
BorrLim3	L					1.00
ClCashBal3	E	-0.74	-0.65	-1.00		1.00
Consp3	G					
TERM VAL	E				-1.00	
RuFert3	L					
OPFert3	L					
CoFert3	L					
RuLab3	L					
OPLab3	L					
CoLab3	L					
RuCap3	L					
OPCap3	L					
CoCap3	L					
RuYield3	G					
OPYield3	G					
CoYield3	G					
F S	L					
F SC	L					
F C	L					
F P	L					
SL S	L					
SL SC	L					
SL C	L					
SL P	L					
ST S	L					
ST SC	L					
ST C	L					
ST P	L					

	Save3	Consp3	CshSur3	CshDef3	TermVal
>ObjFn-MAX	N		0.85	-0.85	0.85
OpCashBal1	E				
TaxInc1	E				
TaxDed1	E				
Exp1	E				
TaxLim11	L				
TaxLim12	L				
BorrLim1	L				
ClCashBal1	E				
Consp1	G				
RuFert1	L				
OPFert1	L				
CoFert1	L				
RuLab1	L				
OPLab1	L				
CoLab1	L				
RuCap1	L				
OPCap1	L				
CoCap1	L				
RuYield1	G				
OPYield1	G				
CoYield1	G				
OPCashBal2	E				
TaxInc2	E				
TaxDed2	E				
Exp2	E				
TaxLim21	L				
TaxLim22	L				
BorrLim2	L				
ClCashBal2	E				
Consp2	G				
RuFert2	L				
OPFert2	L				
CoFert2	L				
RuLab2	L				
OPLab2	L				
CoLab2	L				
RuCap2	L				
OPCap2	L				
CoCap2	L				

RuYield2	G				
OPYield2	G				
CoYield2	G				
OpCashBal3	E	1.00			
TaxInc3	E	-0.05			
TaxDed3	E				
Exp3	E				
TaxLim31	L				
TaxLim32	L				
BorrLim3	L				
ClCashBal3	E	-1.00	1.00	1.00	-1.00
Consmp3	G		1.00	-0.01	
TERM VAL	E				1.00
RuFert3	L				
OPFert3	L				
CoFert3	L				
RuLab3	L				
OPLab3	L				
CoLab3	L				
RuCap3	L				
OPCap3	L				
CoCap3	L				
RuYield3	G				
OPYield3	G				
CoYield3	G				
F S	L				
F SC	L				
F C	L				
F P	L				
SL S	L				
SL SC	L				
SL C	L				
SL P	L				
ST S	L				
ST SC	L				
ST C	L				
ST P	L				

Key:

Crops: Ru = Rubber  
 OP = Oil Palm  
 Co = Cocoa

Soils:            Slope    Texture

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F S = Flat      Sandy  
 Sl SC = Sloping    Sandy Clay  
 St C = Steep      Clay  
 F P = Flat      Peat

APPENDIX 5

OPTIMAL SOLUTION

CROP - LAND ALLOCATION MODEL

GULP 4.2 (C) Copyright 1988 Optimal Software

User: A.Guha

ID: CLAM

Optimal Solution

Problem name : TLP R=5%  
 Problem direction : MAX  
 Objective Function value : 20282856.061000  
 Number of iterations : 105

Activities

No	Name	Level	Shadow Cost	Lower Obj	Objective	Upper Obj
1	RUFS1	Z	0.0000	9385.3812	-INFINITY	0.0000 9385.3812
2	RUFSC1	Z	0.0000	11046.2812	-INFINITY	0.0000 11046.2812
3	RUFC1	Z	0.0000	12463.2312	-INFINITY	0.0000 12463.2312
4	RUFF1	Z	0.0000	19543.7312	-INFINITY	0.0000 19543.7312
5	RUSLS1	Z	0.0000	8813.0463	-INFINITY	0.0000 8813.0463
6	RUSLSC1	Z	0.0000	13297.6463	-INFINITY	0.0000 13297.6463
7	RUSLC1	Z	0.0000	13283.1963	-INFINITY	0.0000 13283.1963
8	RUSLP1	Z	0.0000	1298.9662	-INFINITY	0.0000 1298.9662
9	RUSTS1	D	0.0000	0.0000	-61.2000	0.0000 66.2650
10	RUSTSC1	Z	0.0000	61.2000	-INFINITY	0.0000 61.2000
11	RUSTC1	Z	0.0000	136.0000	-INFINITY	0.0000 136.0000
12	RUSTP1	Z	0.0000	1298.9662	-INFINITY	0.0000 1298.9662
13	OPFS1	Z	0.0000	47.3965	-INFINITY	0.0000 47.3965
14	OPFSC1	Z	0.0000	96.5349	-INFINITY	0.0000 96.5349
15	OPFC1	Z	0.0000	114.2233	-INFINITY	0.0000 114.2233
16	OPFP1	A	46.3320	0.0000	-38.9290	0.0000 0.6980
17	OPSL1	Z	0.0000	9385.5349	-INFINITY	0.0000 9385.5349
18	OPSLSC1	Z	0.0000	11493.3732	-INFINITY	0.0000 11493.3732
19	OPSLC1	Z	0.0000	9102.1616	-INFINITY	0.0000 9102.1616
20	OPSLP1	Z	0.0000	3292.1280	-INFINITY	0.0000 3292.1280
21	OPSTS1	Z	0.0000	7833.3502	-INFINITY	0.0000 7833.3502
22	OPSTSC1	Z	0.0000	6590.4886	-INFINITY	0.0000 6590.4886
23	OPSTC1	Z	0.0000	5347.6269	-INFINITY	0.0000 5347.6269
24	OPSTP1	Z	0.0000	3292.1280	-INFINITY	0.0000 3292.1280

No	Name	Level	Shadow Cost	Lower Obj	Objective	Upper Obj
25	COFS1	Z	0.0000	1441.8849	-INFINITY	0.0000 1441.8849
26	COFSC1	Z	0.0000	3632.3349	-INFINITY	0.0000 3632.3349
27	COFC1	Z	0.0000	3059.4349	-INFINITY	0.0000 3059.4349
28	COFP1	Z	0.0000	22067.1349	-INFINITY	0.0000 22067.1349
29	COSLS1	A	100.0000	0.0000	-184.4500	0.0000 INFINITY
30	COSLSC1	A	100.0000	0.0000	-75.6500	0.0000 INFINITY
31	COSLC1	A	32.5002	0.0000	-0.8101	0.0000 45.1793
32	COSLP1	Z	0.0000	3822.3699	-INFINITY	0.0000 3822.3699
33	COSTS1	Z	0.0000	6019.4537	-INFINITY	0.0000 6019.4537
34	COSTSC1	Z	0.0000	4259.9537	-INFINITY	0.0000 4259.9537
35	COSTC1	Z	0.0000	5114.2037	-INFINITY	0.0000 5114.2037
36	COSTP1	Z	0.0000	3822.3699	-INFINITY	0.0000 3822.3699
37	SellRu1	A	0.0000	0.0000	-13.2348	0.0000 INFINITY
38	SellOP1	A	0.0000	0.0000	-761.7372	0.0000 INFINITY
39	SellCo1	A	0.0000	0.0000	-10.5290	0.0000 INFINITY
40	RuFert1	Z	0.0000	473.3212	-INFINITY	0.0000 473.3212
41	OPFert1	A	30.5792	0.0000	-58.9833	0.0000 1.0576
42	CoFert1	A	153.4501	0.0000	-1.2274	0.0000 68.4535
43	RuLab1	Z	0.0000	18528.7427	-INFINITY	0.0000 18528.7427
44	OPLab1	A	0.7320	0.0000	-2463.8604	0.0000 44.1776
45	CoLab1	A	4.6500	0.0000	-40.5038	0.0000 2258.9669
46	RuCap1	D	0.0000	0.0000	-2.7591	0.0000 0.9466
47	OPCap1	A	2779.9228	0.0000	-0.6488	0.0000 0.0116
48	CoCap1	A	22087.5151	0.0000	-0.0085	0.0000 0.4756
49	TaxInc11	Z	0.0000	3.6032	-INFINITY	0.0000 3.6032
50	TaxInc12	Z	0.0000	4.1957	-INFINITY	0.0000 4.1957
51	TaxInc13	Z	0.0000	4.4008	-INFINITY	0.0000 4.4008
52	TaxDct1	A	40188.8819	0.0000	-3.7246	0.0000 0.3088
53	TaxLoss1	A	156033.4811	0.0000	-0.5143	0.0000 0.5379
54	TotCost1	A	196222.3629	0.0000	-0.5400	0.0000 0.3094
55	Borr1	Z	0.0000	0.0147	-INFINITY	0.0000 0.0147
56	Save1	A	803777.6371	0.0000	-0.5648	0.0000 0.0154
57	Consmpl	A	18257.0942	0.0000	-54.3280	0.0000 2.2936
58	CshSur1	A	825709.4247	0.0000	-0.5433	0.0000 0.0229
59	CshDef1	Z	0.0000	0.0228	-INFINITY	0.0000 0.0228
60	RUFS2	Z	0.0000	9317.3812	-INFINITY	0.0000 9317.3812
61	RUFSC2	Z	0.0000	10978.2812	-INFINITY	0.0000 10978.2812
62	RUFC2	Z	0.0000	12395.2312	-INFINITY	0.0000 12395.2312
63	RUFP2	Z	0.0000	18965.7312	-INFINITY	0.0000 18965.7312
64	RUSLS2	Z	0.0000	8745.0463	-INFINITY	0.0000 8745.0463
65	RUSLSC2	Z	0.0000	13229.6463	-INFINITY	0.0000 13229.6463
66	RUSLC2	Z	0.0000	13215.1963	-INFINITY	0.0000 13215.1963
67	RUSLP2	Z	0.0000	720.9662	-INFINITY	0.0000 720.9662
68	RUSTS2	Z	0.0000	0.0000	-INFINITY	0.0000 0.0000
69	RUSTSC2	Z	0.0000	0.0000	-INFINITY	0.0000 0.0000
70	RUSTC2	D	0.0000	0.0000	-94.5833	0.0000 54.5558
71	RUSTP2	Z	0.0000	720.9662	-INFINITY	0.0000 720.9662
72	OPFS2	A	100.0000	0.0000	-47.3965	0.0000 INFINITY
73	OPFSC2	A	100.0000	0.0000	-96.5349	0.0000 INFINITY
74	OPFC2	A	100.0000	0.0000	-114.2233	0.0000 INFINITY
75	OPFP2	A	53.6680	0.0000	-0.6980	0.0000 38.9290

No	Name	Level	Shadow Cost	Lower Obj	Objective	Upper Obj
76	OPSL2	Z	0.0000	8490.3651	-INFINITY	0.0000 8490.3651
77	OPSLC2	Z	0.0000	10634.0651	-INFINITY	0.0000 10634.0651
78	OPSLC2	Z	0.0000	8278.7151	-INFINITY	0.0000 8278.7151
79	OPSLP2	Z	0.0000	1475.2350	-INFINITY	0.0000 1475.2350
80	OPSTS2	Z	0.0000	6902.3188	-INFINITY	0.0000 6902.3188
81	OPSTSC2	Z	0.0000	5695.3188	-INFINITY	0.0000 5695.3188
82	OPSTC2	Z	0.0000	4488.3188	-INFINITY	0.0000 4488.3188
83	OPSTP2	Z	0.0000	1475.2350	-INFINITY	0.0000 1475.2350
84	COFS2	Z	0.0000	2476.3349	-INFINITY	0.0000 2476.3349
85	COFSC2	Z	0.0000	2958.2849	-INFINITY	0.0000 2958.2849
86	COFC2	Z	0.0000	3243.8849	-INFINITY	0.0000 3243.8849
87	COFP2	Z	0.0000	19956.5849	-INFINITY	0.0000 19956.5849
88	COSLS2	Z	0.0000	184.4500	-INFINITY	0.0000 184.4500
89	COSLSC2	Z	0.0000	75.6500	-INFINITY	0.0000 75.6500
90	COSLC2	A	67.4998	0.0000	-45.1793	0.0000 0.8101
91	COSLP2	Z	0.0000	1711.8199	-INFINITY	0.0000 1711.8199
92	COSTS2	Z	0.0000	5353.9037	-INFINITY	0.0000 5353.9037
93	COSTSC2	Z	0.0000	1894.4037	-INFINITY	0.0000 1894.4037
94	COSTC2	Z	0.0000	3598.6537	-INFINITY	0.0000 3598.6537
95	COSTP2	Z	0.0000	1711.8199	-INFINITY	0.0000 1711.8199
96	SellRu2	A	0.0000	0.0000	-7.7211	0.0000 INFINITY
97	SellOP2	A	0.0000	0.0000	-444.3939	0.0000 INFINITY
98	SellCo2	A	0.0000	0.0000	-6.1426	0.0000 INFINITY
99	RuFert2	D	0.0000	0.0000	-899.7441	0.0000 389.6845
100	OPFert2	A	264.0000	0.0000	-942.7728	0.0000 1080.9581
101	CoFert2	A	198.0000	0.0000	-1086.4311	0.0000 1080.9581
102	RuLab2	Z	0.0000	3266.8162	-INFINITY	0.0000 3266.8162
103	DPLab2	A	6.0513	0.0000	-120.3459	0.0000 6711.8955
104	CoLab2	A	4.8375	0.0000	-9035.8676	0.0000 162.0153
105	RuCap2	A	0.0000	0.0000	-1.7995	0.0000 0.7794
106	OpCap2	A	24000.0000	0.0000	-10.3705	0.0000 3.6032
107	CoCap2	A	28500.0000	0.0000	-7.5478	0.0000 3.6032
108	TaxInc21	Z	0.0000	1.3015	-INFINITY	0.0000 1.3015
109	TaxInc22	Z	0.0000	1.8553	-INFINITY	0.0000 1.8553
110	TaxInc23	Z	0.0000	2.0470	-INFINITY	0.0000 2.0470
111	TaxDct2	A	17295.4812	0.0000	-1.3444	0.0000 0.1800
112	TaxLoss2	A	462504.3199	0.0000	-0.2133	0.0000 0.9395
113	TotCost2	A	479799.8011	0.0000	-0.2197	0.0000 0.1771
114	Borr2	Z	0.0000	0.0086	-INFINITY	0.0000 0.0086
115	Save2	A	345909.6236	0.0000	-4.5076	0.0000 0.0090
116	Consm2	A	13497.0802	0.0000	-433.5902	0.0000 2.1373
117	CshSur2	A	349708.0245	0.0000	-4.3359	0.0000 0.0214
118	CshDef2	Z	0.0000	0.0213	-INFINITY	0.0000 0.0213
119	RUF3	Z	0.0000	9317.3812	-INFINITY	0.0000 9317.3812
120	RUFSC3	Z	0.0000	10974.0312	-INFINITY	0.0000 10974.0312
121	RUF3	Z	0.0000	12930.7312	-INFINITY	0.0000 12930.7312
122	RUFF3	Z	0.0000	18455.7312	-INFINITY	0.0000 18455.7312
123	RUSL3	Z	0.0000	8745.0463	-INFINITY	0.0000 8745.0463
124	RUSLSC3	Z	0.0000	13229.6463	-INFINITY	0.0000 13229.6463
125	RUSLC3	Z	0.0000	13215.1963	-INFINITY	0.0000 13215.1963
126	RUSLP3	Z	0.0000	210.9662	-INFINITY	0.0000 210.9662

No	Name	Level	Shadow Cost	Lower Obj	Objective	Upper Obj
127	RUSTS3	A	100.0000	0.0000	-66.2650	0.0000 61.2000
128	RUSTSC3	A	100.0000	0.0000	-61.2000	0.0000 INFINITY
129	RUSTC3	A	100.0000	0.0000	-54.5558	0.0000 94.5833
130	RUSTP3	Z	0.0000	210.9662	-INFINITY	0.0000 210.9662
131	OPFS3	Z	0.0000	622.2300	-INFINITY	0.0000 622.2300
132	OPFSC3	Z	0.0000	622.2300	-INFINITY	0.0000 622.2300
133	OPFC3	Z	0.0000	622.2300	-INFINITY	0.0000 622.2300
134	OPFP3	Z	0.0000	622.2300	-INFINITY	0.0000 622.2300
135	OPSL3	Z	0.0000	8262.5951	-INFINITY	0.0000 8262.5951
136	OPSLSC3	Z	0.0000	10406.2951	-INFINITY	0.0000 10406.2951
137	OPSLC3	Z	0.0000	8050.9451	-INFINITY	0.0000 8050.9451
138	OPSLP3	Z	0.0000	397.4651	-INFINITY	0.0000 397.4651
139	OPSTS3	Z	0.0000	6674.5488	-INFINITY	0.0000 6674.5488
140	OPSTSC3	Z	0.0000	5467.5488	-INFINITY	0.0000 5467.5488
141	OPSTC3	Z	0.0000	4260.5488	-INFINITY	0.0000 4260.5488
142	OPSTP3	Z	0.0000	397.4651	-INFINITY	0.0000 397.4651
143	COFS3	Z	0.0000	1795.1294	-INFINITY	0.0000 1795.1294
144	COFSC3	Z	0.0000	2277.9294	-INFINITY	0.0000 2277.9294
145	COFC3	Z	0.0000	2554.1794	-INFINITY	0.0000 2554.1794
146	COFP3	Z	0.0000	18704.1794	-INFINITY	0.0000 18704.1794
147	COSLS3	Z	0.0000	717.0445	-INFINITY	0.0000 717.0445
148	COSLSC3	Z	0.0000	922.7445	-INFINITY	0.0000 922.7445
149	COSLC3	Z	0.0000	824.1445	-INFINITY	0.0000 824.1445
150	COSLP3	Z	0.0000	459.4144	-INFINITY	0.0000 459.4144
151	COSTS3	Z	0.0000	3846.4982	-INFINITY	0.0000 3846.4982
152	COSTSC3	Z	0.0000	386.9982	-INFINITY	0.0000 386.9982
153	COSTC3	Z	0.0000	2091.2482	-INFINITY	0.0000 2091.2482
154	COSTP3	Z	0.0000	459.4144	-INFINITY	0.0000 459.4144
155	SellRu3	A	0.0000	0.0000	-1.2462	0.0000 INFINITY
156	SellDP3	A	185.3282	0.0000	-9.7322	0.0000 0.1745
157	SellCo3	A	0.0000	0.0000	-0.9914	0.0000 INFINITY
158	RuFert3	A	42.0000	0.0000	-2764.2728	0.0000 390.4372
159	OPFert3	A	264.0000	0.0000	-2184.6741	0.0000 390.4372
160	CoFert3	A	198.0000	0.0000	-12198.4017	0.0000 390.4372
161	RuLab3	A	5.0100	0.0000	-10911.1661	0.0000 3904.3718
162	OPLab3	A	3.9212	0.0000	-410.5919	0.0000 3904.3718
163	CoLab3	A	3.5700	0.0000	-11294.8345	0.0000 202.5191
164	RuCap3	A	21000.0000	0.0000	-5.5285	0.0000 1.3015
165	OPCap3	A	24000.0000	0.0000	-24.0314	0.0000 1.3015
166	CoCap3	A	28500.0000	0.0000	-84.7468	0.0000 1.3015
167	TaxInc31	A	12000.0000	0.0000	-0.2962	0.0000 INFINITY
168	TaxInc32	A	12000.0000	0.0000	-0.0752	0.0000 INFINITY
169	TaxInc33	Z	0.0000	0.0013	-INFINITY	0.0000 0.0013
170	TaxDct3	Z	0.0000	0.5538	-INFINITY	0.0000 0.5538
171	TaxLoss3	A	849708.0246	0.0000	-0.5560	0.0000 0.3547
172	TotCost3	A	849708.0246	0.0000	-3.3507	0.0000 0.3547
173	Borr3	A	500000.0000	0.0000	-1.2364	0.0000 INFINITY
174	Save3	Z	0.0000	1.2738	-INFINITY	0.0000 1.2738
175	Consm3	A	10000.0000	0.0000	-INFINITY	0.0000 0.8500
176	CshSur3	Z	0.0000	0.0085	-INFINITY	0.8500 0.8585
177	CshDef3	A	489120.0000	0.0000	-0.8521	-0.8500 -0.8416
178	TermVal	A	24351303.601	0.0000	0.8479	0.8500 0.9653

Constraints

No	Name	Slack	Shadow Price	Lower Lim	Limit	Upper Lim	
1	OpCashBal1	E	0.0000	2.5731	970289.6986	1000000.000	1061705.564
2	TaxInc1	E	0.0000	5.8821	-11601.5808	0.0000	24095.4168
3	TaxDed1	E	0.0000	-6.1762	77051.9840	100000.0000	111049.1246
4	Exp1	E	0.0000	-2.5731	-61705.5646	0.0000	29710.3014
5	TaxLim11	L	12000.0000	0.0000	0.0000	12000.0000	INFINITY
6	TaxLim12	L	12000.0000	0.0000	0.0000	12000.0000	INFINITY
7	BorrLim1	L	500000.0000	0.0000	0.0000	500000.0000	INFINITY
8	ClCashBal1	E	0.0000	2.2789	-34073.1734	0.0000	70766.8487
9	Consp1	G	0.0000	-2.2789	-8374.7035	10000.0000	44073.1734
10	RuFert1	L	0.0000	1379.5530	-0.0000	0.0000	0.0000
11	OPFert1	L	0.0000	1852.8743	-36.8304	0.0000	30.5792
12	CoFert1	L	0.0000	1852.8743	-36.8304	0.0000	76.4934
13	RuLab1	L	0.0000	0.0000	-0.0000	0.0000	INFINITY
14	OPLab1	L	0.0000	18528.7427	-1.2000	0.0000	0.7320
15	CoLab1	L	0.0000	18528.7427	-3.0000	0.0000	5.6465
16	RuCap1	L	0.0000	6.1762	-11049.1246	0.0000	0.0000
17	OPCap1	L	0.0000	6.1762	-11049.1246	0.0000	2779.9228
18	CoCap1	L	0.0000	6.1762	-11049.1246	0.0000	22948.0160
19	RuYield1	G	0.0000	-13.2348	-10709.0741	0.0000	0.0000
20	OPYield1	G	0.0000	-761.7372	-186.0650	0.0000	0.0000
21	CoYield1	G	0.0000	-10.5290	-13461.1267	0.0000	0.0000
22	OPCashBal2	E	0.0000	2.3017	-33735.8153	0.0000	70066.1868
23	TaxInc2	E	0.0000	3.4316	-18469.6919	0.0000	38362.1088
24	TaxDed2	E	0.0000	-3.6032	63464.6583	100000.0000	117591.2176
25	Exp2	E	0.0000	-2.3017	-70066.1868	0.0000	33735.8153
26	TaxLim21	L	12000.0000	0.0000	0.0000	12000.0000	INFINITY
27	TaxLim22	L	12000.0000	0.0000	0.0000	12000.0000	INFINITY
28	BorrLim2	L	500000.0000	0.0000	0.0000	500000.0000	INFINITY
29	ClCashBal2	E	0.0000	2.1302	-37126.2647	0.0000	77107.8386
30	Consp2	G	0.0000	-2.1302	-3542.1022	10000.0000	47126.2647
31	RuFert2	L	0.0000	1080.9581	-58.6374	0.0000	0.0000
32	OPFert2	L	0.0000	1080.9581	-58.6374	0.0000	121.7845
33	CoFert2	L	0.0000	1080.9581	-58.6374	0.0000	121.7845
34	RuLab2	L	0.0000	7542.7647	-0.0000	0.0000	1.6700
35	OPLab2	L	0.0000	10809.5809	-2.4000	0.0000	6.0513
36	CoLab2	L	0.0000	10809.5809	-2.6667	0.0000	4.7071
37	RuCap2	L	0.0000	3.6032	-17591.2176	0.0000	0.0000
38	OPCap2	L	0.0000	3.6032	-17591.2176	0.0000	24000.0000
39	CoCap2	L	0.0000	3.6032	-17591.2176	0.0000	28500.0000
40	RuYield2	G	0.0000	-7.7211	-17049.8261	0.0000	0.0000
41	OPYield2	G	0.0000	-444.3939	-296.2325	0.0000	0.0000
42	CoYield2	G	0.0000	-6.1426	-21431.3457	0.0000	0.0000
43	OpCashBal3	E	0.0000	2.1515	-36758.6779	0.0000	76344.3946
44	TaxInc3	E	0.0000	0.5538	-19538.0819	0.0000	24000.0000
45	TaxDed3	E	0.0000	-1.3015	23655.6054	100000.0000	136758.6779
46	Exp3	E	0.0000	-2.1515	-76344.3946	0.0000	36758.6779
47	TaxLim31	L	0.0000	0.2962	0.0000	12000.0000	31538.0819
48	TaxLim32	L	0.0000	0.0752	0.0000	12000.0000	31538.0819

No	Name	Slack	Shadow Price	Lower Lim	Limit	Upper Lim	
49	BorrLim3	L	0.0000	1.2364	461306.6548	500000.0000	580362.5207
50	ClCashBal3	E	0.0000	0.8500	-INFINITY	0.0000	489120.0000
51	Consm3	G	0.0000	-0.8500	-0.0000	10000.0000	INFINITY
52	TERM VAL	E	0.0000	0.8500	-24351303.6	0.0000	INFINITY
53	RuFert3	L	0.0000	390.4372	-122.5289	0.0000	42.0000
54	OPFert3	L	0.0000	390.4372	-122.5289	0.0000	254.4813
55	CoFert3	L	0.0000	390.4372	-122.5289	0.0000	198.0000
56	RuLab3	L	0.0000	3904.3718	-12.2529	0.0000	5.0100
57	OPLab3	L	0.0000	3904.3718	-12.2529	0.0000	3.9212
58	CoLab3	L	0.0000	3904.3718	-12.2529	0.0000	3.5325
59	RuCap3	L	0.0000	1.3015	-36758.6779	0.0000	21000.0000
60	OPCap3	L	0.0000	1.3015	-36758.6779	0.0000	24000.0000
61	CoCap3	L	0.0000	1.3015	-36758.6779	0.0000	28500.0000
62	RuYield3	G	0.0000	-1.2462	-10666.6667	0.0000	0.0000
63	OPYield3	G	0.0000	-71.7233	-185.3282	0.0000	150.8732
64	CoYield3	G	0.0000	-0.9914	-13407.8212	0.0000	0.0000
65	F S	L	0.0000	17298.7150	17.5693	100.0000	139.6891
66	F SC	L	0.0000	17908.7150	17.5693	100.0000	139.6891
67	F C	L	0.0000	18074.7650	17.5693	100.0000	139.6891
68	F P	L	0.0000	18244.7650	46.3320	100.0000	139.6891
69	SL S	L	0.0000	20179.0801	65.4028	100.0000	116.6581
70	SL SC	L	0.0000	23512.7801	65.4028	100.0000	116.6581
71	SL C	L	0.0000	22347.4301	65.4028	100.0000	134.1741
72	SL P	L	0.0000	0.0000	-0.0000	0.0000	INFINITY
73	ST S	L	0.0000	15021.0338	-0.0000	100.0000	326.7654
74	ST SC	L	0.0000	15004.0338	0.0000	100.0000	326.7654
75	ST C	L	0.0000	14987.0338	0.0000	100.0000	326.7654
76	ST P	L	0.0000	0.0000	-0.0000	0.0000	INFINITY

## *Acknowledgement*

My interest into looking at how perennial crop investment decisions should be made was generated by contacts with Malaysian and Indonesian plantation managers while working as a field agronomist at Agricultural Research and Advisory Bureau. It was their often repeated queries on what and where they should plant that made me realize how incapable I was in making such decisions.

For introducing me to the decision making tools available, I am greatly indebted to my supervisor Professor Anton D. Meister, as well as to Professor Allan Rae and Dr. Doren Chadee. Together with other faculty members of the Dept. of Agri. Econ. and Business at Massey Univ., they are largely responsible for making my study of Economics a rewarding experience.

I would also like to record my thanks to colleagues at the Bureau for collecting and sending me data requested as well as for discussions on the extent to which individual factors are important when it comes to deciding on what crop should be planted on a particular soil and/or under a particular agro-climatic regime.