TOWARDS RATIONAL FARM PLANS FOR LAND SETTLEMENT IN INDONESIA: A STUDY OF LAND DEVELOPMENT USING LINEAR PROGRAMMING AND SIMULATION TECHNIQUES

by

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A sub-thesis submitted in partial fulfilment of the requirements for the degree of Master of Agricultural Development Economics in the Australian National University.

September, 1974

DECLARATION

Except where otherwise indicated, this sub-thesis is my own work.

September, 1974 M. A. Wardhani

ACKNOWLEDGEMENTS

I would like to thank most sincerely the many people without whose help this study would not have been completed.

In particular, my debt is to my thesis supervisors Drs. Dan Etherington and Richard Manning and also to Dr. Graham Donaldson, who first interested me in the potential use of Monte Carlo Simulation.

Dr. Colin Barlow was always a source of encouragement. Mr. Murray Ray and Mrs. Gloria Robbins were most helpful in finding the "bugs" in my computer programs.

I wish also to express my thanks to those in various official institutions who labour behind the titles of their departments but who make studies like mine possible: to the Australian Government's Colombo Plan scholarship; to the foreign students section of the Department of Education; and to my own Ministry of Agriculture.

My apologies and thanks go to the patient secretaries who typed the thesis at various stages, particularly Mrs. Pauline Lyall and Miss Jennie Hall, and my English tutors, Mr. Kevin Lyall and Miss Jean Deffenbaugh.

Finally, my heartfelt thanks go to my wife who encouraged me even when she was having to adapt to a foreign culture.

A B S T R A C T

In this study linear programming and Monte Carlo simulation are employed in complementary fashion to investigate efficient resource allocation in land settlement at the micro-level of the family farm. The Second Five Year Development Plan (1974-78) emphasises land settlement as an integral part of enhancing the economic development of Indonesia. The thesis argues that it is crucially important to design the family farm - the core form of agricultural organisation in land settlement schemes - as a viable unit capable of providing the settlers with a reasonable income and of contributing surpluses in the context of regional development. This double-pronged approach differs from the previous policy (in operation since 1905) which laid more stress on the 'social-humanitarian' aspects with the result that the settlers tend to 'bring their poverty with them' to the new areas.

The settlement scheme of Way Seputih in Central Lampung is taken as a case study. This scheme, initially settled over the period 1954 to 1965 and intended for sawah cultivation, will be provided for by an irrigation scheme which is being constructed. In 1970, about 870 hectares out of a total of 17,100 hectares were being irrigated in this way. The analysis uses the average farm as its model and as the basis of the input-output matrix. Enterprises currently operated, as well as potentially suitable ones, are investigated.

The optimal linear programming solution interestingly shows a close similarity to the existing farming pattern with capital being in extremely short supply. With current technology, the available labour is insufficient to cultivate even a holding of less than the minimum

size stipulated by the 1960 Agrarian Law. However, the optimal solution does use more land and labour than current practice and generates considerably higher incomes.

The dual solution provides particularly valuable information in that it highlights the resource constraints which are found to be shortages of capital, land preparation and harvesting labour, and non-sawah land. Parametric programming is applied subsequently to investigate the effects of relaxing these constraints on the supply of resources. The improved technology which accompanies the available irrigation should be coupled with crop diversification to improve resource productivity, farm incomes and work load distribution and to resolve the water shortage in the dry season. However, the full benefits of these measures will not be realised unless bullocks (or hand tractors), credit (at least in the initial stage of intensification) and labour-saving devices of harvesting (using sickle rather than the traditional ani-ani) are provided at the same time. The additional amount of these resources required is calculated (Chapter 5). These are some of the ways available to improve the present condition of the settlers.

The effect of additional non-sawah land (though hardly applicable to Way Seputih, where no reserved land is destined for the settlers) is analysed to investigate the appropriate size of holding. A trade-off diagram showing the relationship between farm size, expected income, and labour absorption capacity is presented (Chapter 5). The range of size of settlement farmscan be more constrained if the objective of settlement in terms of income and employment - the two aspects having high priority in the present National Development Plan - is more clearly defined. An example of the possible implications is given in Chapter 7).

Since any linear programming solution is unique the analysis proceeds with Monte Carlo simulation, using the same input-output matrix, to generate a range of sub-optimal solutions which can be presented as alternative options to the relevant decision-makers (farmers or land settlement administrators). A multi-objective function considering farm income and labour use as its variables is also analysed. It is shown that sub-optimal solutions are important when objectives additional to income are taken into consideration. Another particular merit of the wide variability of solutions is that it explicitly includes a wider range of farmers with their individual management preferences as well as with their actual resource supplies.

The analysis suggests that linear programming and simulation could be readily justified for such a group approach to farm planning (say an ecological zone of a settlement scheme) but would clearly be too expensive to be used for any particular individual farm. The main aim of the study is to show the usefulness of these analytical techniques. However, the actual results must be treated with great caution owing to the limitations of the data and of the static model used. The results do indicate further study with better data and a more appropriate model incorporating the dynamic elements of a developing agricultural system would be desirable. The whole-farm approach adopted in this study is rare in agricultural planning in Indonesia but is shown to be clearly worth pursuing.

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CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

Among the many problems facing Indonesia in enhancing economic development are the high rate of population growth and the regional imbalance in population distribution. In 1971, the Indonesian population was more than 119 million, the fifth largest in the world after China, India, Russia and U.S.A. At the present growth rate of about 2.1 per cent per annum, the population will double within a period of less than 35 years, with the consequent need to provide more food, clothing, housing, education, health facilities, employment and so on. This is a heavy burden for the Indonesian economy, the structure of which is still heavily agrarian with more than 80 per cent of the population living in the agricultural sector, and a per capita income of less than US$100 per annum (Soebroto, 1973).

The problem is aggravated by the imbalance in the distribution of population between Java-Bali and the rest of the archipelago. About 63.8 per cent of the population live in Java, whose area comprises less than 7 per cent of Indonesia. In 1971, the population densities in Java and Bali reached 568 and 377 persons/sq. km respectively, whereas in the rest of Indonesia, it was only 22 persons/sq. km (Takahashi et al., 1974). Table 1.1 shows this distribution. Such a situation will obviously hinder the optimal allocation of national resources.

TABLE 1.1

POPULATION DISTRIBUTION IN INDONESIA, 1971

REGION	AREA[1] (sq. km.)	POPULATION[2] (thousands)	POPULATION DENSITY (persons/ sq. km.)
JAVA-BALI			
D.K.I. Jakarta Raya	592	4,576	7,730
D.I. Yogyakarta	3,090	2,490	806
Central Java	34,353	21,876	637
East Java	46,866	25,527	545
West Java	49,145	21,631	440
Bali	5,623	2,120	377
TOTAL	139,669 (6.81)	78,220 (65.64)	560
MAIN OUTER ISLANDS			
Sumatra	523,097	20,820	40
Sulawesi	229,108	8,535	37
Kalimantan	550,173	5,107	9
Irian Jaya	421,981	923	2
TOTAL	1,724,359 (85.49)	35,385 (29.69)	20.5
OTHER ISLANDS	155,334 (7.70)	5,577 (4.67)	36
INDONESIA	2,019,362 (100.0)	119,182 (100.0)	59

SOURCE: 1. Statistical Pocketbook of Indonesia, 1971;

2. Population Census, 1971;

both as cited by Takahashi et. al. (1974).

An agricultural census conducted in 1963 found that 52 per cent of the farms in Java, more than 4.1 million, were under 0.5 hectares, excluding those farms under 0.1 hectares which were not enumerated in the census and which totalled about 2 million. There were another 2 million landless households. This situation clearly indicates the lack of sufficient land for the growing population of Java (Sajogyo, 1973).

The marginal product of the rural labour force in Java has been practically zero. In contrast, the huge potential land resource in the outer islands of Sumatra - Kalimantan, Sulawesi and Irian Jaya - has remained untapped due to lack of manpower. Here, an estimated 53 million hectares of land comprising 18 million hectares of jungle, 20 million hectares of 'alang-alang' grass (Imperata cylindrica) and 15 million hectares of tidal swamps are convertible into agriculture (Tojib Hadiwidjaja, 1970).

Beginning in 1905, the Dutch Colonial Government organised a scheme of land colonisation in the outer islands, mainly in Lampung, and up to the outbreak of World War II about 40,000 families (200,000 people) had been settled. The scheme was interrupted by the war but the Indonesian Government resumed the venture - termed transmigration - in 1950 and it has been continued up to the present time. Some ambitious plans were proposed in the 1950s and early 1960s to try to curb the population problem in Java but, during the period 1950-1971, only 112,508 families (464,692 people) were settled (IBRD, 1972). In the peak years of 1953, 1959 and 1965, the number of people resettled never exceeded 54,000, or less than 5 per cent of the population increase in each of those years. At the same time, many people have migrated spontaneously, particularly since the late 1920s.

The fact that the population problem in Java cannot be alleviated just by transmigration and that several other measures will have to be taken simultaneously with transmigration, is obvious. However, the critical problem is whether the existing settlements can be justified economically, especially from the viewpoints of improving the settlers' standard of living and inducing economic development in the new area. Evidence shows that most of the existing settlement schemes will hardly meet these criteria. Apart from the unfavourable conditions of agro-support and agro-milieu external to the farms, the internal organisation of the farm business itself is very weak. Most of the settlers came to the area without sufficient capital and could not obtain credit and lacked knowledge, particularly knowledge of farming systems suitable to the new area.

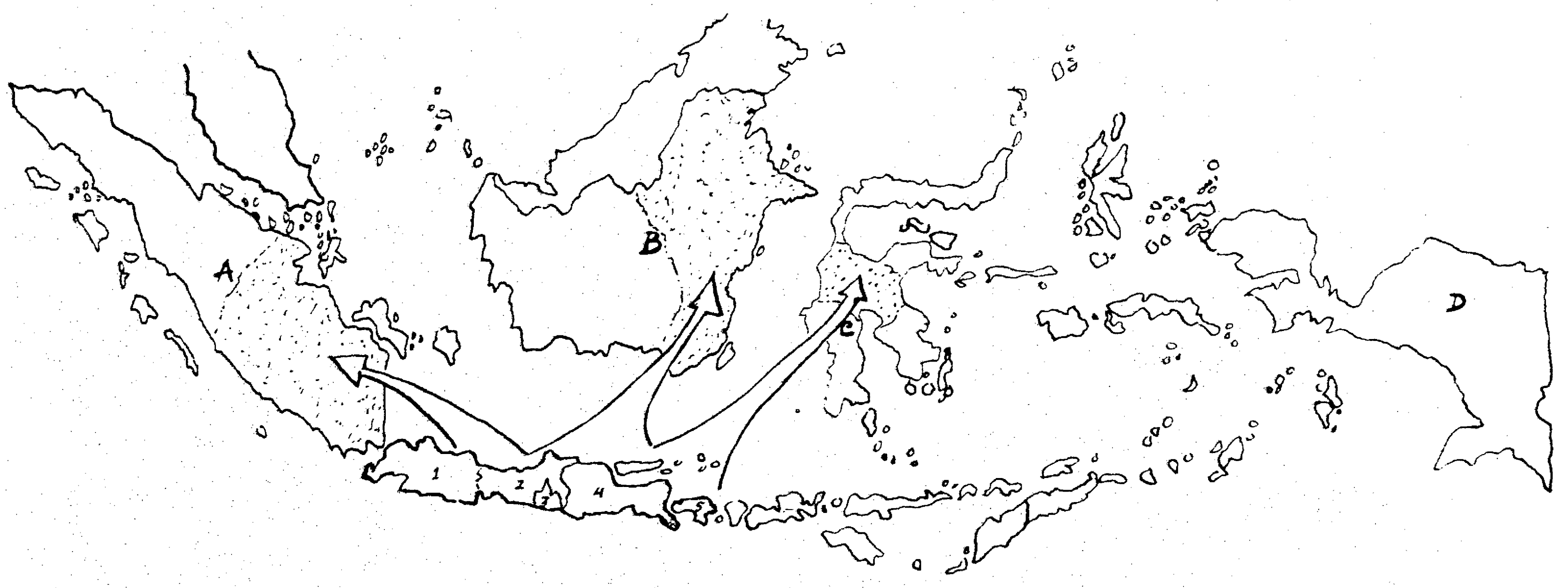
The existing settlement schemes place emphasis on irrigated land (gravitational and tidal irrigation). At present, two hectares of land is the bench-mark size allocated to each settler family. This comprises 0.25 hectares for the homestead plus 1 hectare of irrigated sawah and 0.75 hectares of dryland (Soebiantoro, 1972). Annual crops, mainly rice, are the most important farming activity and no significant perennial cash crops have been developed. Despite the different resource endowment in the outer islands, the local farms have been operated in the same way as those in Java. In many cases, the proposed irrigation had not been provided more than ten years after settlers arrived. Due to the low soil fertility, compared with the young volcanic soils in Java-Bali, the soil productivity decreases very rapidly and subsequently the land is dominated by alang-alang grass where only cassava can properly survive. In a situation where labour is the only source of power available, the settlers' capacity to cultivate the land manually is indeed very limited. The generally unsatisfactory production leads, in many cases, toward stagnation of the newly-built community. In some settlement areas where irrigation has been provided, such as in Southern Lampung, the area becomes overcrowded. Some of the population are the second or third generation of the previous settlers, but many of them are the spontaneous migrants who came voluntarily to the area at their own expense, but were not allotted any land of their own.

In the coming Second Five Year Development Plan (1974-1978) land settlement in the outer islands is given a more important function as an integral part of enhancing economic development. However, it was not until early this decade that the transmigration policy was reviewed in order that the scheme not be treated as a 'social-humanitarian' undertaking to transfer poor and landless people. Rather, transmigration is to be carried out in the perspective of regional development and more favourable spatial distribution of economic activity, thus improving national resource allocation. The present strategy of land settlement aims at establishing growth centres and growth poles in the new regions, based on agro-development. In this way, it is expected that more and more spontaneous migrants from the densely populated Java-Bali will be encouraged into the outer islands (Soebroto, 1973).

The above strategy requires a concentrated and integrated effort and should be implemented in areas with immediate growth potential which promise good prospects for economic growth and development. At present, not less than 112 recorded schemes are spread throughout the country (Soebiantoro, 1972). The areas given priority for settlement in the present plan are shown in Figure 1.1

FIGURE 1.1

INDONESIAN ARCHIPELAGO: PRIORITY AREAS FOR LAND SETTLEMENT



<u>LEGEND</u>: (i) Region and population density (persons/sq. km.)

1. West Java	- 440	A. Sumatra	- 40
2. Central Java	- 637	B. Kalimantan	- 9
3. D.I. Yogyakarta	- 806	C. Sulawesi	- 37
4. East Java	- 545	D. Irian Jaya	- 2
5. Bali	- 377		

(ii) Shaded areas are the priority for land settlement.

<u>SOURCE</u>: Soebroto (1973).
"Indonesia's Economic Structure and its Population Problem", <u>Indonesia Magazine</u>, No.20/1973 (cover page) with data revised.

Up to the present time land settlement is mainly based on family farms with mutual aids and communal works ('gotong royong') among the settlers. Thus the performance of the family farm, i.e. at the micro level, is critical to the scheme and will in many respects determine its success or failure. Failure of the schemes will not only ruin and dishearten the settlers and their future generations, but will also waste scarce national resources and economic opportunities.

Taking for granted that the Government will continue to give priority to establish family farms in the land settlement policy, this study is concerned primarily with the problem of resource allocation at the family farm level. Recent developments in farm planning techniques, such as the use of linear programming and simulation, facilitate the study of better resource allocation. In this study, these techniques are applied to the smallholder condition of family farms as a case study on one of the existing settlement schemes.

1.2 Objectives of the Study

The main aim of this study is to show the merits of linear programming (LP) and simulation techniques in investigating better resource allocation at the micro-level of the family farm. The manner in which the available resources of land, water, labour and capital should be allocated to establish more rational farm plans is analysed. A rational plan is viewed here from two angles. From the farmer's point of view, rational farm plans are those combinations of crops and livestock which are feasible, profitable, and satisfy a specified management preference. In terms of the social economic viewpoint, rational farm plans are farming systems which are more conducive to development, taking into consideration the crucial issues of farm surpluses, market orientation, and technological change, to facilitate structural transformation of the economy. The optimal and sub-optimal farm plans are examined, given a particular level of resource supply constraints and a range of alternative crops and livestock enterprises.

Applying the above techniques to the farm model of the present settlement scheme - a case study - the analysis is aimed at identifying the constraints facing the existing farms and at investigating possible alternatives to improve the present farmers' conditions. By examining a wider range of resource supplies than currently apply and alternative crops/livestock enterprises to those in operation at present, the analysis is also expected to throw some light on various viable farm plans which might be useful for planning future land settlement of similar types. In particular, the analysis looks at the question of farm size.

1.3 Methodology

1.3.1 The techniques

Firstly, the family farm is viewed as a whole entity, with a set of resource supplies on which a range of alternative enterprises of crops and livestock can be chosen to satisfy the objective of farming. The farm as a system is expressed in the form of an input-output matrix. Linear programming is applied to solve the optimal resource allocation, while at the same time its dual solution provides the shadow prices of the existing resources and identifies the resources which are binding. Parametric programming is then used to investigate the effects of relaxing these binding constraints.

Since for a particular set of resource supplies linear programming provides only a single solution, with no alternative options to be presented to those decision-makers on resource allocation, the analysis proceeds with simulation to generate a range of alternative sub-optimal solutions. From these solutions, a multi-objective function is also analysed to provide more information for decision-making.

This study, as a first orientation to the problem, and to make the analysis simple but practical, employs only the simple static model. A more sophisticated model taking into consideration the dynamic change of the system over time and the inclusion of transfer activities between stages of development, such as capital transfer, would be more appropriate to study land development.

1.3.2 The data

The writer has not had an opportunity to conduct his own survey to collect the necessary data for this analysis and no previous study of this kind seems to have been done in Indonesia for the purpose of comparison. The fact that data limitation was the major obstacle to the analysis has to be realised from the start. The approach adopted to get more realistic data for the construction of the farm model and its input-output matrix, therefore, was reliance on the available secondary data and careful judgments. The results thus obtained and the conclusions drawn should be applied only with great caution. It is stressed here that the main purpose is to demonstrate the usefulness of the analytical techniques.

Because of the availability of some previous studies, Way Seputih in the province of Lampung is taken as a case study. An irrigation project is being carried out to provide irrigation for this settlement area. Studies on water supply, land capability and socio-economic aspects have been undertaken. The fact that Lampung is the largest and probably the best example of land settlement performance in Indonesia since the beginning in 1905 indicates is could provide useful background information for this analysis. In addition, a regional planning study for Lampung has just been completed by the University of Bonn (1973) and statistical data from official publications is available up to 1972. Wherever it was available, data from experimental stations and field trials was used. Where necessary, relevant data from other countries was also consulted.

The average farm in Way Seputih is used as the farm model studied. Though the approach might not be the best from the individual farmer's point of view, it might be justified for land settlement purposes. Furthermore, the range of sub-optimal solutions provided by the simulation analysis includes a wider coverage of individual farmer's situations, as far as their typical resource supplies and particular management preferences are concerned.

1.4 Organisation of the Study

The analytical techniques employed - linear programming and simulation - are discussed briefly in Chapter 2 and the data used is presented in Chapter 3. Chapter 4 presents the construction of the input-output matrix. The results of the linear programming analysis are discussed in Chapter 5 and the simulation solutions are discussed in Chapter 6. Chapter 7 concludes the analyses.

CHAPTER 2

LINEAR PROGRAMMING AND SIMULATION TECHNIQUES FOR FARM PLANNING

The increasingly mathematical orientation of economic analysis and the advances of computer technology have brought many developments to farm management. Among these are the use of linear programming (LP) and simulation techniques for farm planning. These techniques treat the farm as a whole entity, a new and important approach compared to the more common inter-commodity budget study.

Whole-farm planning considers the best allocation of available resources between alternative products and processes according to farmers' objectives and subject to a set of constraints. Linear programming can be used to maximise (or minimise) an objective function, say profit (or cost), which yields a single optimum solution. It also provides information on factors limiting further increase in the maximum value of the objective function. This optimum solution can be regarded as a guide in decision-making, but more valuable - as in this study - as a guide for further analysis.

Simulation techniques have been developed to represent the range of real farm situations in a mathematical model. When a model has been built, it can be followed by a second stage of experimentation using alternative sets of data. The simulation used in this analysis, however, is not an attempt to simulate the existing farm situation. Rather, it is a type of numerical simulation using a random method of selecting a set of better alternative enterprise combinations. Thus it presents a range of alternative farm plans, on both existing and new enterprises, for farmers to choose from. By this method, a great amount of information is derived and can be used for further analysis, such as the consideration of multi-objective functions or other sensitivity analyses. Because of the random selection method used in this planning technique, it is commonly called Monte Carlo simulation.

The practical use of both linear programming and simulation for peasant agriculture is still very limited. Some attempts have been undertaken to apply linear programming for peasant conditions such as those in Kenya, India, Nigeria, Malaysia, Thailand and some others, for example, studies carried out by Clayton (1961, 1963, 1964), Heyer (1971), Desai (1961), Johl and Kahlon (1967), Ogunfowora (1970), Leonard (1969), Thodey (1973), etc. The results show some promise and at least indicate the lines along which further development should take place. Lack of adequate data is a problem common to all these studies and formulating the model itself is another problem, considering the complexities and diverse nature of peasant farming. This situation also suggests that it is less appropriate to consider single objective function in smallholder farming.

Monte Carlo simulation is a relatively new technique which has only been applied to farm planning in the last decade, but it appears never to have been applied to smallholder agriculture in the less developed countries. However, linear programming and Monte Carlo simulation can be used in a complementary fashion to provide useful information on the alternatives open to farmers thus assisting in making more informed decisions regarding farm resource allocation.

Considering the laborious preparation required to handle a problem using linear programming and simulation, it is argued that the use of these techniques might be more justified in a group or regional approach rather than for the individual farmer because of the small scale operation of peasant farming and the detailed nature of data needed. A similar view has been expressed by Barnard (1963) and Heyer (1969) regarding the use of linear programming.

2.1 Linear Programming

Dantzig (1951) developed the simplex method to solve linear programming problems. Once a problem has been formulated, to maximise (or minimise) an objective function subject to linear equations or inequalities is strictly a mathematical problem. Some scientists, like the French mathematician Fourier and the Russian mathematician Kantorovich, solved similar problems earlier; Fourier in 1826 and Kantorovich in 1939 (van de Panne, 1971). At the present time computer development makes linear programming computations relatively easy, using programs packages developed for this purpose, for example, SIMPDX, UHELP and MPS/360. The first two packages are used in the present analysis; they have been written by the University of Wisconsin and the University of Houston, respectively. Large problems can be handled with great precision, a tedious, if not impossible, task if performed manually, In most computer programs the revised simplex or explicit inverse method is used.

There are some problems associated with using a simple linear programming algorithm due to the assumptions made for this technique and the nature of its solution. In the conventional linear programming problem, several assumptions are made:

a) A linear input-output relationship or constant return to scale in the process of production;

b) Both resources and farm enterprises (activities) are infinitely divisible and additive in order to achieve a maximum value of the objective function, and

c) There is a finite number of alternative activities which can be independently selected.

Some improvements have also been suggested. It is not the purpose of this study to discuss these problems; rather it will exploit the advantages provided by the technique and use them as guidance for further analysis.

Mathematically, the linear programming problem can be expressed most succinctly in matrix notation:

$$\text{Maximise } CX$$
$$\text{Subject to } AX \leq b$$
$$X \geq 0$$

where C is a row vector of order n (the gross margins), b is a column vector of order m (the RHS), and A is an m x n matrix (the coefficients).

But for ease of comparison with Monte Carlo simulation it is expressed here in terms of summation notation:

$$\text{Maximise } Z = \sum_{j=1}^{n} c_j x_j$$

$$\text{Subject to } \sum_{j=1}^{n} a_{ij} x_j \leq b_i \qquad i = 1,2.....m$$

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

where $Z = f(x)$ is the objective function, c_j and x_j are, respectively, the gross margin and level of j^{th} activity; a_{ij} is the input-output coefficient of the j^{th} activity using the i^{th} resource; b_i is the supply of i^{th} resource (the right hand sides or RHS).

Linear programming gives a single optimum solution, that is a unique combination of activities which gives the maximum value of the objective function. Geometrically, the solution is a corner point where the hyperplane formed by the objective function just touches the m-dimensional 'sphere' formed by the specified constraints. From the viewpoint of land settlement planning, the single linear programming solution does not provide alternatives which might be presented to a prospective settler. In fact, the unique solution might not conform to those of his preference which were not included in the original objective function.

On the other hand, the linear programming solution is a 'saddle-point' between a primal (say maximisation) and dual (say minimisation) problem and it is the dual solution that is of particular interest because it provides the marginal value products or shadow prices of each activity and resource supply. The marginal value products of unexhausted resources are zero, otherwise they have a certain positive value which reflects the relative scarcity of the resource concerned. A positive value for the MVP represents the increased value of the objective function when one unit of the resource is added. A high shadow price of an excluded activity means a high reduction of the objective function if that activity is forced into the plan. This valuable information provides a guide to which direction expansion or reduction of the business is worth-while.

For the purpose of land settlement analysis, the above information can be used to detect which constraints are binding, and at what level they are binding. A careful study of the existing performance may show, at least in principle if not in exact magnitude, how future settlement schemes should be designed in terms of land allocation, cropping pattern, credit facilities, draft powers, processing and marketing facilities, and the like. For existing settlements the technique can show

how to improve income levels by means of better allocation of available resources, or by introducing more profitable crops/livestock or by improving the resource supply of those inputs which are particularly scarce at present.

2.2 Parametric Programming

Parametric programming is used to investigate the sensitivity of the optimum solution to changes in the parameters of the resource supplies, the coefficients and the objective function. Parametric analysis of a more sophisticated nature is able to provide information on the range of values of the parameters over which the optimal solutions are stable or changing as well as the degree of change.

For the purpose of the present study, it is important to examine the impact of changing the critical parameters of the resource supplies, particularly those which are found to be binding at present or when a certain land development policy is imposed. Such analysis is expected to provide alternative options for policy decisions. However, even with changes in key parameters, there is a single optimum solution for each change and around each optimum solution there are an almost infinite number of sub-optimal solutions.

The reverse simplex method can generate sub-optimal solutions for a given lower limit value of the objective function. In principle, it is formed by forcing non-basic activities into the solution (van de Panne, 1971). Other methods can also be used for this purpose, such as the Monte Carlo simulation which is applied in the present study.

2.3 Simulation

Monte Carlo simulation can be used to examine sub-optimal solutions and to provide a simple method of resolving the integer problem.

Moreover, the method is more amenable to 'modelling'. For example, specified preferences such as the maximum number of enterprises included in any one plan or the specified weight and interval level for each activity can be attached in advance. The method also permits the inclusion of multiple objective functions and has other advantages, such as the incorporation of non-linear relationships. economies of scale and interactions between activities (Carlsson et al., 1969).

The use of this method was first put forward by Lindgren and Carlsson in 1966. Comparison of linear programming to this method has also been undertaken (Stryg, 1967; Dent and Thompson, 1967). The present exercise follows the operating procedure outlined by Donaldson and Webster of Wye College (1968), with some minor differences. It is simpler in terms of including only 'primary activities' which are independently selectable but it includes a multi-step process suggested by Stryg (1967) and Carlsson et al. (1969). It also proceeds with a multiple objective function.

Expressed in mathematical formulation, the simulation model can be specified as follows:

1) The Objective Function

$$Z_k = f_k(x_1, x_2, \ldots\ldots x_j \ldots\ldots x_n), \qquad k = 1,2\ldots\ldots h;$$

where k is the number of objective functions, and x_j indicates the level of j^{th} activity. The functions can be of arbitrary form. For example, in the present study Z is the Total Gross Margin (TGM):

$$Z_1 = \sum_{j=1}^{n} c_j x_j \qquad (c_j = \text{gross margin of } j^{th} \text{ activity}).$$

2) The Constraints

i) $\sum_{j=1}^{n} a_{ij}x_j \le b_i$ $\qquad i = 1,2......m$

where a_{ij} is the input-output coefficient for the j^{th} activity using the i^{th} resource; b_i is the supply of i^{th} resource (the RHS). If the scale effect in the use of resources is incorporated, the constraints can be in the form:

$$\sum_{j=1}^{n} R_{ij} < b_i, \quad \text{where} \begin{cases} R_{ij} = q_{ij} + a_{ij}x_j & \text{if } x_j \neq 0 \\ R_{ij} = 0 & \text{if } x_j = 0 \end{cases}$$

ii) $x_j \ge 0$ and

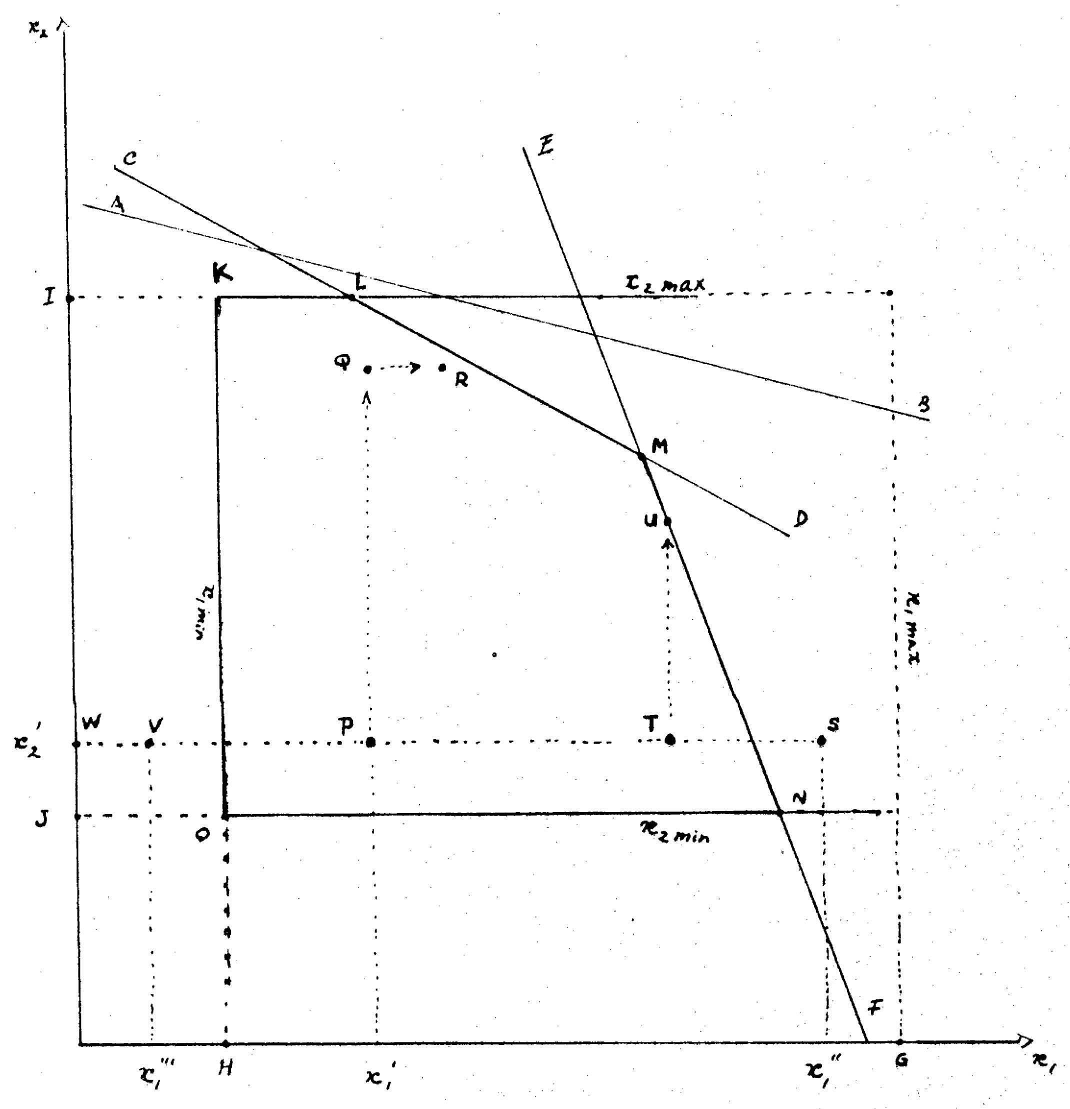
$x_{j-min} \le x_j \le x_{j-max}$ $\qquad$ (x_j is an integer)

Basically, the method is a process based on a random number technique to select a number of activities and to assign to them integer values (levels) which are subject to the given sets of resource supplies and constraints. This first step is followed by an expansion stage, whereby the levels of the activities chosen are increased in the same order as they were selected, up to a maximum which the remaining constraints allow. By this method of selection and expansion, all solutions will be integer values next to the boundary of the feasible region formed by the constraints. The value of the objective function is then calculated. The computer program is designed to repeat the selection procedure many hundreds of times and store some specified number of plans (say, 100) which have the highest value of objective function.

The above selection and expansion process can be illustrated using two production activities, x_1 and x_2, as shown in Figure 2.1:

FIGURE 2.1

AN ILLUSTRATION OF THE SEEKING PROCESS
IN MONTE CARLO SIMULATION



In the above figure, AB, CD and EF are the linear constraints. The activities are specified to be in the range $x_{1min} \le x_1 \le x_{1max}$ and $x_{2min} \le x_2 \le x_{2max}$. Otherwise, they are set equal to zero. All values must be in integer form. Therefore, the feasible region comprises integer points enclosed by the constraint boundary and the permissible levels of x_1 and x_2, i.e., the region KLMNO and those points along the lines GH and IJ. In this example, the linear constraint AB is not binding (inoperative constraint).

Suppose that in the selection process, x_2 is chosen first and given the value x_2^1. Subsequently, x_1 is chosen and given the value x_1^1. Point P is then the level of activity combination in this first stage. In the following stage of the expansion process, x_2 - the first activity selected - is increased up to the limit the constraints allow, in this case up to point Q. Following this, x_1 is increased up to point R, which is the final solution.

However, if x_1 is selected and given the value x_1^{11}, the point S exceeds the constraint EG. Consequently, the x_1 value is reduced and point T is chosen. The value of x_2 is then increased, and point U - by chance lying in the surface of the constraints - is chosen as the final solution. On the other hand, when x_1^{111} is selected instead of x_1^1 or x_1^{11}, its value lies below the minimum specified level, so x_1 is set at zero. Point W is, therefore, the final solution of the activity combination.

The above process of building a feasible plan is repeated as many times as desired. As more plans are tested, the more likely that some plans will approach the optimal solution. Quite clearly, using the above Monte Carlo simulation, the linear programming optimal solution cannot be selected, unless the latter has been formulated as an integer program. Even then, that solution is only one among an extremely large population and the probability of being selected is very small indeed when dealing with a realistic problem composed of, as in this study, 21 activities and 13 constraints. However, depending on the complexity of the problem and the number of replications undertaken, a set of sub-optimal plans close to the optimum can be found. As the number of replications increases some plans in the top group are likely to be duplicated. Table 2.1 shows the results derived from the matrix in the present study, with eight different limits on the number of replications.

TABLE 2.1

THE EFFECT OF THE NUMBER OF REPLICATIONS ON THE TOP HIGHEST PLANS

Replications	Duplication in the Top 20	TGM (per cent of optimal LP)		
		Highest	Lowest of 20	Lowest of 100
101	0	85.3	54.6	13.1
200	1	85.3	64.3	41.5
500	0	86.9	71.6	56.3
1000	1	88.7	75.6	63.3
2000	6	88.7	82.7	70.5
3000	6	88.7	84.2	73.2
4000	7	89.2	85.3	75.5
5000	8	89.2	85.7	77.7

From the above plans and their activity combinations and levels, the total gross margin (TGM) and the remaining constraints are calculated. The TGM is considered in this analysis as the first criterion in the objective function, while family labour use is the second criterion. Plans are selected according to their TGM and the top hundred plans are printed as an answer tableau. Appendix A presents the flow chart and computer program of this simulation.

Since the main purpose of using the simulation method here is to complement the linear programming solution, the same input-output matrix is used in both methods with only a minor change in its structure. The matrix used in the linear programming includes activities of production as well as activities supporting the production. The latter are the labour hiring activities in the peak season periods. However, labour hirings are dependent activities and their inclusion will be assigned only when the family labour supply is not sufficient to perform the production process itself. Therefore, labour hirings are not included in the list of activities to be chosen in the simulation matrix. The level and costs of these activities - unlike those in linear programming - will be calculated separately. In many simulation programs, these activities and others, such as feed and fodder crops or purchasing and selling activities, are termed as 'dependent' or 'derived' activities and are built in with the programs.

A particular weight is assigned to each of the production activities in a cumulative value. The random number generation* produces uniformly distributed real random numbers between 0 and 1.0, and these values are converted into 0 and 100 for the selection process.

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* RAND - the program used - is the one written by Brent (1972) of the Australian National University Computing Centre.

The higher the weight given to an activity, the more likely this activity will be selected. Different weights can be used to specify a farmer's preference towards any alternative activity. Furthermore, different weights can be applied to increase the efficiency of the selection process, when it is known that the inclusion of an activity into any one plan is more profitable. This is done in a multistep process of the simulation, where different weights, and interval reduction, is used in the subsequent phases of the simulation.

Phase I of the multistep process refers to the first run where the activities are assigned equal weights and the only limits on their values are those specified by the constraints. The frequency of appearance of an activity and its levels in the top group plans of Phase I shows the relative advantage of the activity in building feasible and profitable plans. A p-weight or p^2-weight in relation to the above frequency and maximum and minimum activity level based on the interval over which the activity appears in Phase I can be specified in Phase II of the simulation. This multistep process will yield plans with higher TGMs compared with those which appear in Phase I.

CHAPTER 3

BACKGROUND INFORMATION AND SOURCES OF DATA

3.1 WAY SEPUTIH: The Case Study Area

Way Seputih, which is used as a case study in this analysis, is a transmigration scheme which was initially settled over the period 1954 to 1965. The original plans catered for irrigated sawah and the diversion weir for the irrigation system was constructed in the period 1959-1963 but the canals and other works were not started until 1969. The present construction and the establishment of sawahs is expected to be completed by 1978.

Some surveys have been undertaken on the physical and socio-economic aspects of Way Seputih and the present exercise is mainly based on this data. A 1969 survey of the water supply was conducted for the Government by Harza Engineering Consultants (IPB, 1970). The Bogor Institute of Agriculture (IPB) conducted a semi-detailed land classification in 1970 and a survey on the socio-economic aspects of the area in the same year. The data obtained from these sources provide valuable information for the present analysis, but are inadequate. On one hand, the techniques of linear programming and simulation used require more detailed and comprehensive data. On the other hand, the surveys were not primarily designed for farm planning purposes.

The farming system presently practised in the area is still in a transitional stage because of the long delay with irrigation. It was not until 1969-1970 that the first 870 hectares of sawah had been established and planted with rice. The IPB Social Economic Survey provides some farm management data on sawah cultivation which is compared with data on most of the existing dry-land farming.

Additional data for the present analysis, particularly data on suitable alternative crops and technology which can be introduced into the area, have to be gathered from various other relevant sources including data on farming systems in Lampung and Java. Some results from experiments carried out by the Bogor Research Institute of Agriculture are also used. This institute is also conducting some field verification trials in co-operation with the Agricultural Extension Service, some of which are in Lampung and provide useful data. The University of Bonn (1973) is undertaking a Regional Planning Study for the Government including some farm management surveys - one of which is in Lampung - on the various farm types currently existing. Some data on general conditions in Lampung up to 1972 are also available. An agricultural survey report on Way Pangubuan - a similar irrigation project adjacent to Way Seputih - conducted in 1969, provides useful data for comparison (IPB, 1969). Where necessary, reference is made to some sources outside the country, such as Malaysia. Careful subjective adjustments have been made to these various data and the present analysis is conducted on the adjusted data. Therefore, conclusions should only be drawn with great care. However, as mentioned in Chapter 1, the main aim of the analysis is to show the merits of the analytical techniques used.

The main project area consists of two kecamatans in the eastern peneplain, i.e., Terbanggi Besar and Seputih Mataram in the kabupaten of Central Lampung, which were established from the abovementioned transmigration scheme in 1968 and 1969 respectively.

Adequate transportation is essential for agricultural products and supplies in agricultural development. In fact, Mosher (1966) makes it one of his five essentials. Way Seputih, particularly Terbanggi Besar, is well situated in terms of the local transportation network. The main road of Lampung passes through the area, making the two main cities and ports in Southern Sumatra - Tanjung Karang/Teluk Betung and Palembang - more accessible. An old railway line also passes through the area but has become less important in the transport of goods.

3.1.1 Population -

The 1971 population census recorded a total of 111,772 persons in the two kecamatans, 73,337 persons in Terbanggi Besar and 36,435 persons in Seputih Mataran (BPS, 1971). The gross area of Way Seputih is 382.9 sq. km (IPB, 1970) so the population density had reached 292 persons/ sq. km in 1971, nearly four times that of Lampung and eight times that of the whole island of Sumatra. Although Way Seputih has a population density only slightly more than half that of Java, it is still overcrowded. Thus settlers have left an overcrowded Java and established crowded conditions in the new area, on soil which is less fertile than that of Java.

The population of Lampung as a whole has been growing rapidly. The population density in 1971 was 79 persons/sq. km, while the figure was 47 in 1961 and only 10 in 1930 (Lampung, 1971). Within the decade 1961-1971 the population increased by 68.1 per cent or about 5.3 per cent per annum, compared with the national average of 2.1 per cent in the same period. The high population growth in Lampung was probably due to the migrants who came to Lampung, whether organised or spontaneously. In the case of Way Seputih settlement about 80 per cent were migrants, mostly Javanese with some from Bali.

Table 3.1 shows the population growth in each kabupaten and municipality in Lampung. Central Lampung had the highest growth rate (6.9 per cent per annum) and Southern Lampung had the second highest

TABLE 3.1

POPULATION DENSITY AND GROWTH IN LAMPUNG 1961-1971

No.	District/Municipality	Area[1] (km^2)	Census 1961[1]		Census 1971[2]		% Population Growth	
			Total	Density	Total	Density	10 yrs	Annual*
1	Tanjung Karang/ Teluk Betung	52.62	133,901	2,545	198,986	3,782	48.6	4.0
2	Southern Lampung	6,765.88	685,392	101	1,114,765	165	63.4	5.1
3	Central Lampung	9,189.50	514,392	56	998,500	109	94.6	6.9
4	Northern Lampung	19,360.50	337,134	17	464,834	24	41.2	3.5
	Province of Lampung	35,376.50	1,667,819	47	2,777,085	79	68.1	5.3

Source: 1. Lampung, Kantor Sensus dan Statistik, Census Penduduk 1971.

2. Lampung, Kantor Sensus dan Statistik, Lampung dalam Angka 1972.

* The annual rate of population growth, r, is calculated using the formula:

$$(1 + r)^{10} = \frac{P_2}{P_1},$$

where P_2 is the numbers of population in 1971 and P_1 is the number in 1961.

growth rate (5.1 per cent per annum), both rates exceeding that of the municipality (4.0 per cent per annum). The two kabupatens had a population density of more than 100 persons/sq. km, i.e., 109 in Central Lampung and 165 in Southern Lampung. In contrast, Northern Lampung, with the largest land resource had the smallest population growth (3.5 per cent per annum) and is still thinly populated, i.e. 24 persons/sq. km. This situation is worth considering in planning locations for further settlements in Lampung.

The 1971 census also provides the age composition of the population, as presented in Table 3.2:

TABLE 3.2

THE AGE COMPOSITION OF THE POPULATION IN LAMPUNG, 1971

Age Group	Number	Percentage
0 - 4	539,422	19.51
5 - 14	783,502	28.34
15 - 24	425,594	15.39
25 -	1,016,073	36.76

Source: Lampung, Kantor Sensus dan Statistik, Sensus Penduduk 1971, p.7.

In relation to the farmers in Way Seputih, the IPB Socio-Economic Survey found, from 113 sample farmers, the average family size was 6.6 persons with 2.9 adults. When these people first arrived the figures were lower at 4.5 and 2.3 respectively. These data are used in this analysis to estimate the effective work force and labour supply of the farms in the area.

3.1.2 The land -

In 1956, Verstappen (Kampto Utomo, 1957) presented the physiographic basis of transmigration areas in Southern Sumatra. The region was divided into seven zones according to rock type, soils, and morphology as shown in Figure 3.1.

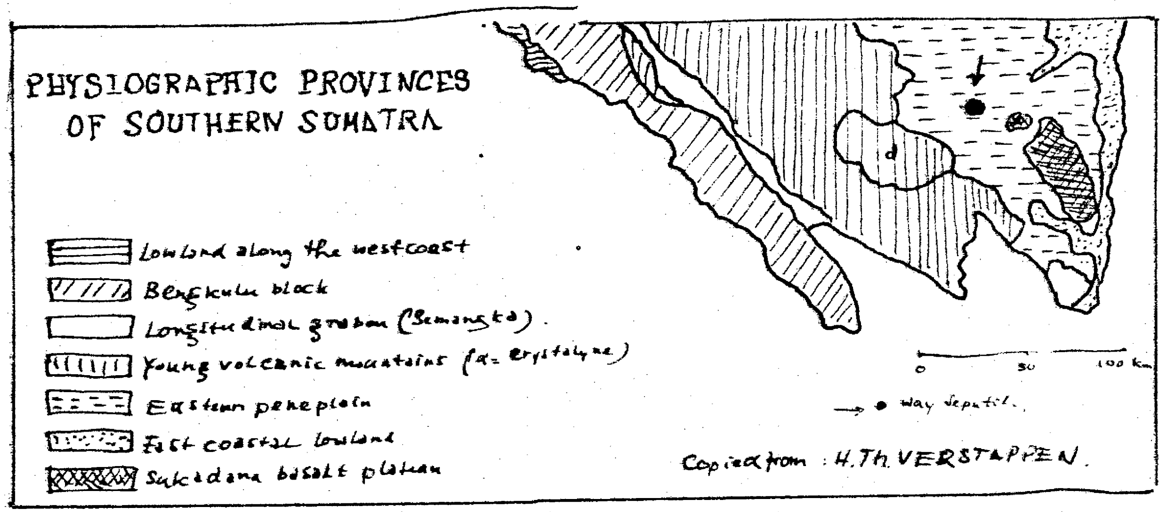
Way Seputih is part of the eastern peneplain zone. The soil type is dominated by Red Yellow Podsolic, which is strongly acid with low base saturation and is usually of low natural fertility.

The land classification undertaken by IPB - though carried out long after the start of the settlement - provides useful guidance for the establishment of sawah. Less than 50 per cent of the gross area is favourable for sawah, only 17,100 hectares being recommended for sawah out of 38,300 ha surveyed including the 1R and 2R land classes with fine texture and clay to sandy clay subsoil. Another 10,000 hectares is class 3R and, though marginally suitable for sawah, is recommended as better suited for diversified crops other than irrigated sawah. These crops include maize, sorghum, beans, sugar cane, etc., or perennial cash crops such as coconut, rubber, coffee, etc. The rest of the land is occupied by hamlets, construction sites, and other places located higher than the planned irrigation canals. Table 3.3 summarises the distribution of the land classes. Appendix B.1 shows the map of this distribution. Apart from land classification for the purposes of irrigated sawah, classification was also made according to general land classes. In addition, a more detailed map (1:25,000) was also prepared by the IPB team.

As a result of the 'reversed planning' (settle first and survey later), the land allocated to individual settlers has been diverted from the initial benchmark. The benchmark allocation was 2 hectares, consisting of .25 hectares for a homestead, .75 hectares of dry-land and 1 hectare of

FIGURE 3.1

THE PHYSIOGRAPHIC BASIS OF TRANSMIGRATION AREAS IN SOUTHERN SUMATRA



Source: Kampto Utomo (1957), Masjarakat Transmigran Spontan.

TABLE 3.3

THE DISTRIBUTION OF LAND CLASSES (FOR IRRIGATED SAWAH) IN WAY SEPUTIH

Land Class	Gross Area (ha)	Net Area* (ha)
1R	6,629	5,966
2R	12,393	11,156
3R	11,160	10,044
No-R**	391	
5R***	7,719	

Notes:

* About 10 per cent is occupied by hamlets, roads, canals, etc.

** Not suitable for sawah.

*** Places located above the planned irrigation system.

Source: IPB (1970), Klassifikasi Tanah, p.16.

sawah. The minimum size of landholding in Indonesia has been stipulated to be 2 hectares under the 1960 Agrarian Law (Soemarsono, 1965). In practice the minimum size is not effectively enforced even in the new settlements.

In 1970, many holdings in Way Seputih were less than 2 hectares. A total of 16,320 families occupied the gross area of 38,300 hectares. Taking into account areas for hamlets, canals, roads and other land not suitable for farming, the average farmland resource (1R, 2R and 3R classes) per family was only 1.66 hectares, comprising 1.05 hectares of potential sawah and .6 hectares of non-sawah land. Table 3.4 shows the land distribution among farmers in the Western, Central and Eastern parts of the area.

Due to the settle first/survey later situation, the difference between the actual holding and its benchmark allocation is in size as well as in the distribution of land type among individual settlers. The settlers had their parcel of land allocated before it was definitely known where the sawah and non-sawah farmland and the homestead blocks should be. The land use right certificate (Surat Hak Pakai) to their parcels was confirmed in 1970 and, subject to certain requirements, the land will be confirmed as a property right sometime in the future. As a result, some settlers got more sawah than others. Furthermore, in the case of construction sites, canals, etc., compensation has to be paid to some settlers if part of their farm is commandeered.

The 1960 Agrarian Law also stipulates the maximum size of holdings, depending upon the type of land and the population density of the area. In an area such as Way Seputih which is classified by regulation as fairly densely populated, people are allowed to possess up to 7.5 hectares of sawah, or up to nine hectares of dry-land, or some combination of the two.

TABLE 3.4

THE FARMLAND RESOURCE IN WAY SEPUTIH 1970
(ha)

Zone	Net Area	Sawah Land (1R & 2R)	Non-Sawah Land (3R)	Population (Families)		Average Farmland per Family		
				Total	Migrants	Total	Sawah	Non-Sawah
Western Part	8,200	4,950	3,250	4,750	3,950	1.72	1.04	0.68
Central Part	6,100	3,640	2,460	4,400	2,600	1.37	0.82	0.55
Eastern Part	12,800	8,510	4,290	7,170	6,500	1.77	1.18	0.59
TOTAL	27,100	17,100	10,000	16,320	13,050	1.66	1.05	0.61

Source: IPB (1970): Survey Social Ekonomi, p.36.

For thinly populated areas, such as Way Seputih itself before settlement took place, the maximum amounts are 15 hectares and 20 hectares respectively.

In the present analysis, an attempt will be made to investigate various farm sizes that can be managed as a family farm.

3.1.3 The climate and water supply -

The area has a tropical monsoon climate influenced by the two big continents (Asia and Australia) and by the general pattern of trade winds. The wet season falls between November and April and from May to October is the dry season.

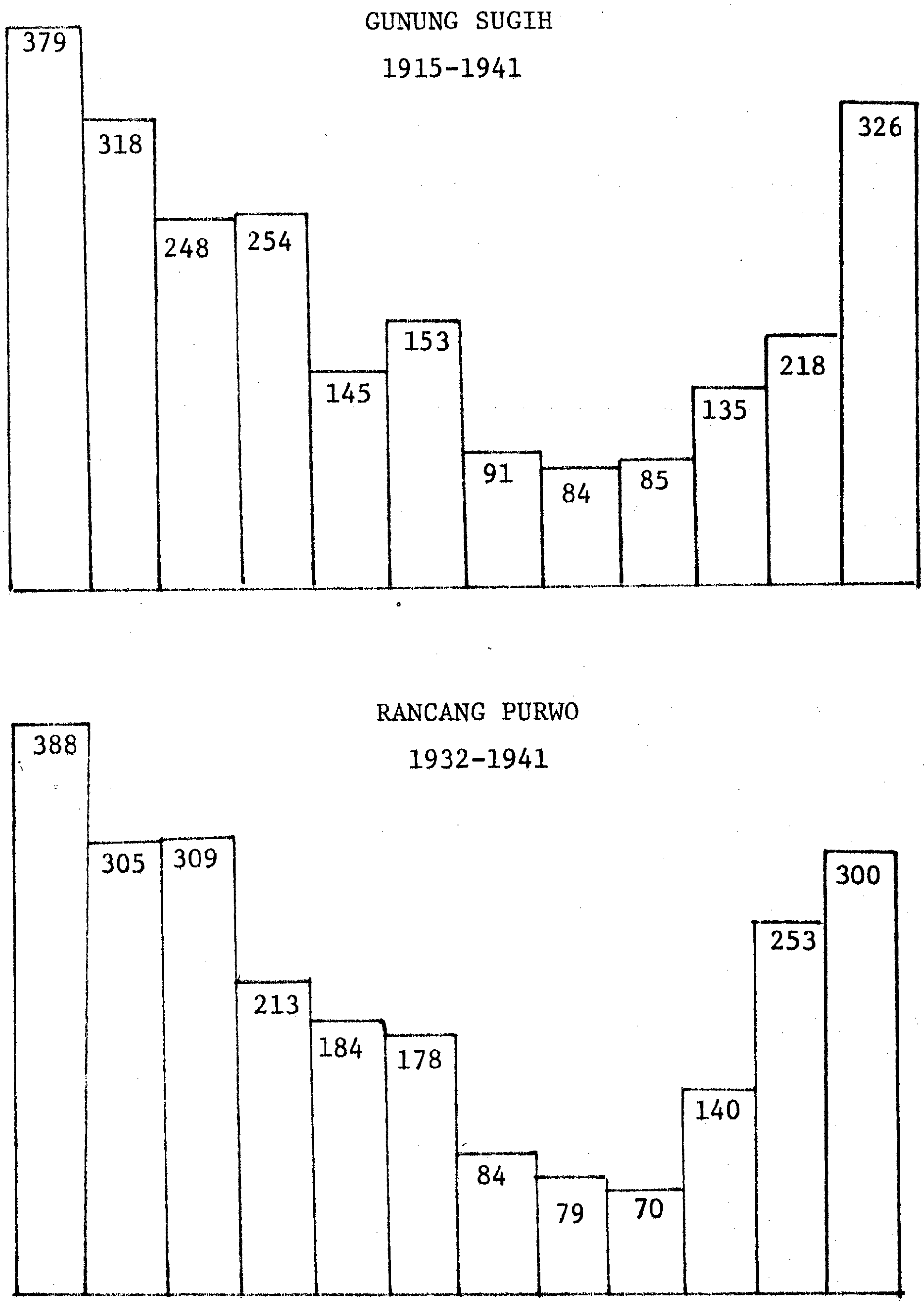
Temperature is always high with an annual mean of 27.5°C. The variation is small, being at its greatest in the dry month of August which has an average minimum of 22.2°C at night and an average maximum of 32.2°C by day. Solar radiation is low due to clouds, especially in the wet season with an average of about 33 per cent. Radiation is higher in the dry season. The low radiation during the day and high temperature at night affects the rate of plant assimilation and the transpiration processes. Consequently the crop yields are affected. Climatological data observed at Branti airport is shown in Appendix B.2.

The rainfall and water supply is very important in farming. The rainfall in Way Seputih is high and exceeds 2400 mm annually. The stations at Guning Sugih and Rancang Purwo show annual rainfalls of 2436 mm and 2503 mm per annum respectively (Bonn, 1973). The monthly distribution, which more or less reveals two distinct seasons, is presented in Figure 3.2.

The water available for irrigation is jointly determined by the quantity of rainfall and evapo-transpiration. The monthly discharge water for Way Seputih catchment area is presented in Table 3.5.

FIGURE 3.2

THE MONTHLY DISTRIBUTION OF RAINFALL



Source: University of Bonn (1973), Sumatra Regional Planning Study, pp.21, 22.

TABLE 3.5

DISCHARGE OF WAY SEPUTIH
(Catchment area: 677.3 sq. km)

Month	Discharge	
	Litre/second	Millions cu. m/month
January	43,307	112.25
February	40,598	105.23
March	33,833	87.69
April	32,479	84.19
May	27,061	70.14
June	21,650	56.12
July	21,461	55.63
August	10,822	28.05
September	8,120	21.05
October	6,765	17.53
November	8,120	21.05
December	21,650	56.12
Average	22,988.83	59.58

Source: University of Bonn (1973). *Sumatra Regional Planning Study*, p.31.

During the dry season, less water is available. According to Harza's report (IPB, 1970) the water supply in the wet season is sufficient to irrigate 25,000 hectares of rice. The dry season water supply is only sufficient to grow about 4,500 hectares of dry season rice (gadu).

Some farmers prefer to double-crop their sawah with rice. The Government encourages this practice, otivated by the desire of Indonesia to be self-sufficient in rice. However, the above water limitation in the dry season does not permit double-cropping of the whole sawah with rice. In Java, where the same situation applies, people grow greater quantities of diversified crops of 'palawija' such as maize, soybean, ground nut, tobacco, red spanish pepper, etc., in the dry season. These crops require less water and some of them are more profitable than rice. Many benefits are claimed for crop diversification (Heady, 1952). The present analysis is also aimed at investigating better crop combinations in the diversification context under conditions where the dry season water supply is considered as one of the constraints.

3.2 Farming Systems

Most of the Way Seputih settlers are still struggling in a temporary pattern of farming while waiting for irrigation water. By necessity, quick yielding annual crops were grown during their early years of settlement but without the application of manure or fertiliser, and without proper rotation, the continuous harvests depleted the unfertile (podsolic) soil very rapidly. Afterwards, alang-alang grass, which is extremely difficult to eradicate, became dominant. No provision for draught power and credit was made to ease the hardship of pioneering. Because of their reliance on manual power the settlers were forced to establish sedentary dry-land farming. Perennial cash crops would actually be better under these conditions, but, as also reported in other schemes (IPB, 1969), an initial lack of investment capital was the prime obstacle to development of the perennial crops. The present general land use (Table 3.6) gives an idea of the extent of the present farming. Some examples of the changes in land use over the period 1954 to 1969, in terms of natural vegetation, the degree of degradation and the intensity of cultivation, is presented (Appendix B.3).

TABLE 3.6

SUMMARY OF PRESENT LAND USE

Usage	ha	%	Remarks
Hamlets	3.860	10.0	10
Sawah	380	1.0	38.6
Rubber	340	0.9	
Sedentary Dryland	11.074	29.0	
Shifting Cultivation	2.965	7.7	
Forest	8.360	21.9	51.2
Alang-Alang Grass	11.250	29.3	
Swamps	63	0.2	

Source: IPB (1970): Klassifikasi Tanah, p.24.

3.2.1 Cropping pattern -

The IPB Social Economic Survey reported that, after the long period of struggling in dry-land conditions, the settlers have found a (relatively) profitable method of dry-land farming, i.e., mixed crops of rice-maize-cassava. If grown together and planted about October-November, the maize can be harvested in February, the rice in April, while the cassava can be harvested gradually during August-September.

This system saves time in land preparation (compared with the same crops grown separately in monoculture) and distributes both work load and income generation (food supply) more evenly during the year. This is the most dominant dry-land system. It is also followed by farmers who have cultivated their first sawah.

Monoculture cassava is the next most profitable system after the mixed crop in the dry-land. The extent of cassava cultivation, both as mono culture and as a mixed crop, stems from the fact that cassava is a less demanding crop in terms of soil, climate and capital, as well as labour. Apart from consumption as a supplement to grains, it has a good market for export (see Appendix B.4 on export records). Small amounts of pulses, sweet potatoes, sugar cane and some perennial crops (mainly rubber, which is cultivated by the indigenous people) are also grown in the dry-land.

The established sawah (870 ha) have been planted with rice in both the wet season and the dry season. The majority of the sawah farmers grow rice alone (58 per cent, mostly double-cropping). Others grow rice as well as the mixed crops rice-maize-cassava (26 per cent) or upland rice (15 per cent), in their dry-land.

The Social Economic Survey clearly indicated that the crops grown, whether in the dryland or sawah, reveal the poor capital pattern of farming (pola kurang modal) characterised by minimal purchased inputs. Fertilizer application to rice in the sawah has been tried by some farmers and shows a very substantial yield increase.

3.2.2 Land cultivated and labour use -

The land is cultivated manually without the aid of cattle or hand tractor. Where alang-alang grass dominates, sedentary dry-land farming requires substantial labour. The amount of land cultivated by the present settlers, therefore, has been very limited. For farms having both sawah and dryland, the average cultivated land in 1970 was 0.85 hectares, and comprised 0.60 hectares of irrigated sawah, 0.24 hectares of dry-land, and 0.01 hectares of swampy land. This was about 40 per cent of their land. In the case of indigenous farmers (dry-land), the figure was higher than the average, i.e., 1.16 hectares, because of the rubber groves cultivated, which alone covered 0.63 hectares in 1970. The other 0.53 hectares was primarily shifting cultivation on the 4.97 hectares of shrubland (Appendix B-5).

Annual crop cultivation demands a great deal of labour and appropriate timing of operations, especially when preparing land, planting, and harvesting. Where alang-alang grass dominates the dry-land, labour requirements for land preparation and weeding are higher than those in sawah, but labour requirements for harvesting are smaller due to the usually lower yield of dry-land crops. Table 3.7 compares the labour use for wet rice, upland rice, and for the mixed crops rice-maize-cassave.

TABLE 3.7

LABOUR USE FOR VARIOUS CROPS

Type of Work	Average of Labour Use (Man days/ha)		
	Irrigated Rice	Upland Rice	Mixed Crops
Nursery	1.19	-	-
Land Preparation	105.00	127.35	129.73
Planting	23.07	23.52	30.41
Maintenance	0.03*	39.12	120.27
Harvest	39.31	14.71	143.24
TOTAL	168.68	204.70	423.65

Note: * This figure appears to have been underestimated.

Source: IPB (1971): Survey Sosial Ekonomi, p. F.20.

The table also indicates the advantage of mixed crops by showing that three crops are grown using nearly the same amount of labour for land preparation as for upland rice cultivation (monoculture). The labour used for crop maintenance and harvesting is higher due to the longer period of crop growth and to the extra crops to be harvested, especially in the case of cassava.

In general, outside labour is hired in the peak periods of land preparation, planting and harvesting, to supplement family labour wherever possible (availability and payment permitting). Mutual aid (sambat-sinambat) among the neighbouring farms is common. Since the land operated is limited and there are near-slack periods between peaks, the available labour supply is not fully utilised. For an average farm family of 2.9 adult members the average on-farm work for the whole of 1970 was only 221 man days among the dry-land farmers and 170 man days among those having sawah. The average number of man days in non man days was 208 and 165 respectively. Non-farm activities comprised petty trading, public works, construction and general labouring, including labouring on other farms. The incomes gained from the non-farm employment, whether total or per man day, were substantially greater than farm income (Table 3.8). However, the total family income levels were still very low, being less than $30/cap./annum.

TABLE 3.8

THE AVERAGE FAMILY INCOMES AND LABOUR USE

Type of Employment		Dry-land Farmer	Sawah Farmer*
ON-FARM EMPLOYMENT			
a) Family labour use	(man days)	221	170
b) Incomes	(Rp)	17,300	26,000
c) Incomes/man day	(Rp/man days)	78.4	153.2
OFF-FARM EMPLOYMENT			
a) Labour use	(man days)	208	165
b) Incomes	(Rp)	44,700	45,200
c) Incomes/man day	(Rp/man days)	215	273.9
TOTAL			
a) Labour use		429	335
b) Incomes		62,000	71,200

Notes: * This group included the army pensioner settlers, whose pensions received were added to their off-farm incomes. The amount was slightly greater than Rp.5,000 per month.

Source: IPB (1971): Survey Sosial Ekonomi, Tables F.5, F.6 and F.18 (compiled for one hectare basis).

3.2.3 The prospects for farming -

The coming irrigation will undoubtedly bring substantial changes to the farming systems in the area. It will be possible to grow a wider variety of crops. Improved technology accompanying the available water, such as the use of HYVs, application of fertilizers and pesticides, which have been practised in other established irrigated areas of Lampung, can be introduced. Multiple cropping will also be made possible.

Some limited information on the possible introduction of these innovations is available. However, a careful study such as field verification trials must be undertaken before they should be actually put into extensive practice. Based on soil analysis, climate and other information, the Soil Survey Team did mention some suitable crops, both annuals and perennials, with the level of fertilizer application and expected yield (Table 3.9). Other crops such as rubber, tobacco and the existing mixed crops are worth considering.

There is a range of crop varieties, fertiliser levels and methods of cultivation that may be considered. Results from some field trials conducted in Lampung (Appendix B.6) provide a rough guide for introducing these innovations to Way Seputih (to be further tested).

The irrigated sawah will be planted mainly with rice in the wet season. In the dry season the diversified annual crops listed in Table 3.9 as well as rice - limited at present by the insufficient water supply - can be grown. In the non-sawah land, perennial crops, as well as the annual crops already cultivated, can be planted.

The Farm Management Study conducted by the University of Bonn (1973) shows that income gained by perennial crop type farms is comparable to that of the best sawah farm. In some spontaneous settlements, where Government

TABLE 3.9

SOME CROPS SUITABLE FOR WAY SEPUTIH

Crop	Yield Potential (tonnes/ha)	Fertilizer (kg/ha)		
		N	P_2O_5	K_2O
Rice	4-6	100	50-90	60
Maize	5-6	90-120	90	60
Sorghum	3-4	80	90	60
Ground Nut	0.8-1.0	-	80	60
Soybean	0.8-1.0	-	80	60
Mungo bean	0.5	-	80	60
Red spanish pepper	1.0	50	50	50
Sugar cane	8-10	150	100	250
Cassava	40-50	120	80	200
Sweet potatoes	20-30	90-100	80	120
Pineapple	20-30,000	100-150	80	100
Rocella	0.2-0.4	80	80	80
Coffee	1-2	50	60	60
Pepper	1-2	50	60	60
Coconut	1-2	1.0	1.5	2.0
		per tree		

Source: IPB (1970): Klassifikosi Tanah, p.26.

intervention in determining the type of cultivation is minimum many Javanese settlers have shown their ability to cultivate excellent pepper. It is therefore a wrong notion to suppose that the Javanese settlers will always stick to their background culture of growing annual crops or paddy in sawah.

The market for agricultural products (and also inputs) plays a very important role for the development of crop production. As a clear example, the growing export market for cassava and maize in the late 1960s has greatly encouraged the production of these crops in Lampung (Appendix B.4). The incentive to grow diversified crops when irrigation becomes available will also necessitate greater service in processing and marketing, as well as making the provision of good agri-support and agri-milieu essential.

CHAPTER 4

THE CONSTRUCTION OF THE INPUT-OUTPUT MATRIX

4.1 The Structure of the Matrix

The computing tableau being used in this analysis consists of three sets of parameters:

(i) a column vector of resource supplies (the RHS);

(ii) a two-dimensional input-output coefficients matrix;

(iii) a row vector of the gross margins for each activity.

A sub-matrix, containing cumulative weights for each activity, the minimum and maximum levels of each activity, and an element to specify the maximum number of activities included in any one plan, is added for simulation.

A given input-output matrix will produce one LP solution which is optimal in terms of maximising the total gross margin (TGM). Variations to particular elements in the RHS by means of parametric LP will provide different optimum solutions. Simulation is then applied to selected matrices, i.e., those that are able to yield specified minimum TGM, to generate a range of sub-optimal solutions.

4.2 The Average Farm of Way Seputih

In this analysis, the average farm - an estimate of the average based on available data presented in Chapter 3 - will be used as a model of the farm studied. Such a farm possesses average resource supplies on which alternative activities of crops-livestock in various combinations can be chosen to establish a feasible and profitable farm plan.

The existing farming systems serve as a valuable source of information for farm planning toward further improvement, and as a basis for comparison. The coming irrigation itself will undoubtedly open new economic opportunities by increasing the productivity of the land and reducing the risk and uncertainty of yield, as well as making multiple cropping possible. However, new feasible and profitable farming systems suitable for Way Seputih are still to be investigated. Hence, a more general model, which includes more reliable irrigation with a wider range of cropping patterns than now applies, is used. Provision is also made for different resource supplies than currently exist. Such an approach is expected to be useful for the purpose of seeking rational farm plans for land settlement.

When the irrigation systems in Way Seputih have been completed the farms will generally be family farms with sawah cultivation (1R and 2R land classes) and irrigable non-sawah land (3R class). There will also be a piece of land for a homestead.

The sawah is usually planted with rice in the wet season. In the dry season, due to a smaller supply of water, only about one-quarter of the sawah can be planted with rice (padi-gadu) but all of the farm can be planted with diversified secondary crops (palawija) such as maize, soybean, ground nut, tobacco, red spanish pepper, sweet potato, mungo bean, etc. To a certain extent, these crops have already been grown in this area and the settlers, who are mostly Javanese, are familiar with them. Improved technology and cultural practices accompanying the irrigation water, such as the use of HYVs, fertilizers, pest and disease control, and better land cultivation, can also be introduced.

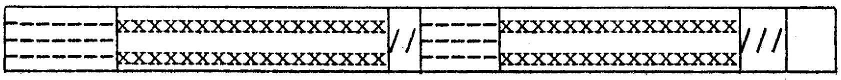
Sawah cultivation has been observed to be highly labour demanding with very uneven labour distribution. The first peak period in labour demand occurs during land preparation and transplanting, while harvest time forms another peak. In the periods between the two peaks, labour demand drops drastically. Outside labour is commonly hired to complete the work in the peak periods, even for small farms of less than half a hectare. Traditionally, exchange labour or mutual aid (sambat-simambat) is practised to solve the problem of labour shortages. More efficient methods of land preparation which involve the use of draught animals or hand-tractors can, therefore, be helpful. To speed up the harvest, sickles can be used rather than the traditional ani-ani. Land preparation for one hectare sawah can be completed within 35 working days using a pair of cattle, and in less than a week if a 7-hp hand tractor is used. However, if manual hoeing is employed, about 127 days labour are necessary. Sickle harvesting takes about 75 man days per hectare, while the traditional ani-ani takes about 200 man days (Birowo, 1973). The shorter habitus of the HYVs also makes ani-ani harvesting rather difficult.

In the dry season, diversified crops of palawija vary in terms of labour requirement, depending on the duration of their growth and technical nature of the crop. Mungo bean matures in 10 weeks, while sweet potatoes can be harvested after about 4 months. Tobacco and vegetables require careful and intensive cultivation, but crops like soybean can be planted after the wet season rice without further land preparation - a common practice in Java. With improved cultivation, however, soybean gives higher yields. As in the case of rice, the phenomena of peak and non-peak, though to a lesser degree, still occurs in the palawija crops. Peak and non-peak periods during the year, therefore, have been differentiated and quantified as labour restrictions.

The diagram in Figure 4.1 defines the periods of peak and non-peak (slack) labour requirements. The 52 weeks of the year are divided into 7 periods of different durations according to the nature of farm operations.

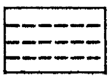
FIGURE 4.1

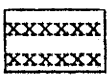
THE DEFINED PERIOD BOUNDARIES OF THE CALENDAR YEAR



Period	I	(PEAKW2)	=	7 weeks
	II	(ORDW1)	=	17 weeks
	III	(PEAKW2)	=	2 weeks
	IV	(PEAKD1)	=	5 weeks
	V	(ORDD1)	=	15 weeks
	VI	(PEAKD2)	=	3 weeks
	VII	(ORDD2)	=	3 weeks

<u>MAJOR ACTIVITY FOR ANNUAL CROPS</u>

 - Land preparation and planting

 - Crop growth/maintenance

 - Harvesting

 - Slack

These are decided upon by considering sawah cultivation as the prime farming activity since rice cultivation has the most binding time constraints mainly because of water supply limitations.

The need for internal generation of working capital is another important constraint. If the cropping pattern is simply double-cropping of sawah the two harvests will be the only sources of farm income. However, most expenditures on farm operations, as well as those on essential family consumption, are made outside the periods in which income is received. This situation becomes a serious problem when the income gained from the two harvests is not sufficient to meet the basic family consumption requirements and to finance farm operations in the following season.

In framing the general pattern of the whole farm operation, it is therefore necessary to take into account the above situation of seasonal labour needs and restricted income generation. The crops or livestock activity on non-sawah land can be synchronised accordingly. The mixed cropping maize-rice-cassava with three harvests in the existing dry-land falls in different periods - maize and rice in period II and cassava in period V - and is the traditional way of meeting those restrictions. Leguminous crops such as soybean and mungo bean might also be worth introducing. These crops can meet the requirements of spreading the work load during period II as well as building up soil fertility. Sorghum has another agronomical characteristic. It can be harvested twice or three times. After the first harvest, which falls in period II, the stalk can be cut down in such a way that some of the bottom vertebrae remain. Provided enough fertilizer is applied, the sorghum can then be reharvested in period V with equal yield (LP_3, 1971).

Apart from annual crops, the perennial cash crops such as rubber, coconut, coffee and, to a limited extent, pepper, are also suitable for Way

Seputih land and are recommended by the IPB Soil Survey Team. At present these perennial crops are still not extensively grown by the migrants in most settlement schemes in Lampung - except maybe perennial trees in their homestead - due primarily to a lack of investment capital (IPB, 1969). Poultry rearing can also improve labour distribution and income stream generation.

4.3 Resource Supplies and Constraints

Land, water, labour and capital are the main inputs for crop and livestock production. Constraints on the use of resources may be technical, economic, or social and institutional. The constraints ascribed to any resource supply will limit the levels of the alternative activities. Based on the information discussed in Chapter 3, Table 4.1 summarises the resource supplies at the base (present) situation and are discussed below.

4.3.1 Land and water resources -

The average farm has about one hectare of sawah and seven-tenths of one hectare of non-sawah land. Due to the small scale of operation and because of the integer solutions expected from the simulation analysis, the land size is measured in decare units (1.0 ha = 10.0 da). Because of the apparent distinction between the two seasons of sawah cultivation, sawah land is divided into wet season and dry season land (WIRSL and DIRSL). Rice in the wet season sawah can be planted up to 10 ha. The same maximum level of 10 da applies to dry season rice but the binding constraint is the limited supply of irrigation water in the dry season (DIRWAT). However, dry season sawah can be planted with palawija crops as well as gadu.

The water supply limits the growing of gadu to only 25 per cent of the dry season sawah or 2.5 da. Diversified palawija crops require less water than rice. No detailed data is available concerning the water

TABLE 4.1

THE RESOURCE SUPPLIES AT THE BASE SITUATION

Name*	Code	Maximum Supply	Unit
W. S. Sawah Land	WIRSL	10	da
D. S. Sawah Land	DIRSL	10	da
D. S. Irrigation Water	DIRWAT	2.5	unit
Non-sawah Land	SANOL	7	da
W. S. First Peak Labour	PEAKW1	840	man hours
W. S. Slack Labour	URDW1	1,139	"
W. S. Second Peak Labour	PEAKW2	240	"
D. S. First Peak Labour	PEAKD1	600	"
D. S. First Slack Labour	ORDD1	1,105	"
D. S. Second Peak Labour	PEAKD2	360	"
D. S. Second Slack Labour	ORDD2	201	"
W. S. First Hired Labour	HIPW1	75	"
W. S. Second Hired Labour	HIPW2	120	"
D. S. First Hired Labour	HIPD1	50	"
D. S. Second Hired Labour	HIPD2	180	"
W. S. Cash Supply	CASWET	5,000	rupiah
D. S. Cash Supply	CADRY	5,000	"

Note:

* W. S. = Wet Season

D. S. = Dry Season

The duration of periods of labour supply is as defined in Figure 4.1.

requirements for each of these crops but it is estimated to be between .12 and .20 of the amount rice requires (which is about 275 cu. m per da) (IPB, 1969). For convenience, this amount is referred to as one unit. The total water supply for the dry season is, therefore, 2.5 units, which means rice can be planted in up to 2.5 da in the dry season by leaving other fields idle.

The non-sawah land (SANOL) has the upper limit of 7.0 da. It can be planted with perennial crops as well as with annuals. For the purpose of further analysis - with reasons described later in Chapter 5 - the present limit on the supply of this kind of land will be relaxed. The upper limit then will be the amount stipulated by the 1960 Agrarian Law, namely about 75 da, thus bringing farm size to a total of 85 da.

4.3.2 Labour supply

In the current situation, family labour, mostly in the form of manual labour, is the main source of labour supply for farm operations. Draught animal power is available but only in the ratio of one pair of animals to any twelve farm families. Tractors are unavailable. However, for further analytical purposes, more draught animals or hand-tractors will be assumed to be introduced to assist the farmers in the most labour demanding jobs of land preparation. These power sources need to be expressed in equivalent manhours, since manual land preparation and other forms of power are treated as if they are perfect substitutes.

On the average, farm families in Way Seputih have 6.6 members: the husband or head of the family, the wife, and the children. In this analysis, in relation to labour supply, it will be assumed that one of the children is an adult, two are of school age, and the others are under school age. These assumptions are based on the age composition of the population in Lampung in the 1971 census as presented in section 3.1.1.

Converting these family labour units into standard adult male equivalent units (AME), in line with the Vink study in East Java (Soejono, 1961), yields 1:0.67 and 0.33 for each adult male, adult female, and child, respectively. Since children are not usually available for full time farm jobs the supply of their labour will be assumed to be 50 per cent of their capacity during the peak season and 33 per cent in the non-peak season. The farmer's family is assumed to be able to work up to 48 hours a week during the peak season and 30 hours a week during the non-peak season. For a particular cropping pattern with little difference between peak and non-peak periods, as in the case of smallholder rubber, the non-peak hours per week are assumed to be 35. The family labour supply for each of the seven periods of the year is expressed in manhours (Table 4.1). At present, the cattle which can be used for draught power is assumed to be one pair per twelve families, based on the fact that the total number of cattle for 3,273 families is only 906 (IPB, 1971). It is also assumed that 60 per cent of the cattle can be fully used for land preparation, i.e., an average .083 or 1/12 pair per farm. Cattle are usually used from early in the morning for about five working hours. In period I, one pair of cattle will be assumed available for land preparation up to a limit of 180 cattle hours or an average of 15 cattle hours per farm. In period III, this number is set at 10 cattle hours per farm. The rate of work by the cattle is about 3.9 to 6.2 times that of manual hoeing. In this analysis, it will be assumed to be five times faster thus yielding a 'labour' supply from cattle of 75 and 50 manhours equivalent for period I and period III respectively. These values are treated as the existing upper limit of hired labour for land preparation (HIPW1 and HIPD1). Any hired labour is added to the supply of family labour for land preparation in the wet and dry season (PEAK W1) and PEAK D1). Introducing more cattle or hand tractors to Way Seputih will increase the amount of hired labour potentially available.

Hired labour is fairly common in transplanting (or planting) and harvesting and is necessary to perform these jobs. However, a type of labour exchange or mutual aid (sambat-simambat) between neighbouring farmers is more common. Unlike in Java where landless farm labourers are abundant, in Way Seputih, almost all of the farmers work their own land. Potential spontaneous migrants and, to some extent, underemployed urban workers are hired when the crop is harvested. The amount of labour available is assumed to be up to 50 per cent of available family labour for period III and period IV. This labour is usually paid in kind (bawon). With rice, the amount of bawon is about one-sixth to one-ninth of the harvest. For some palawija crops the bawon system is not usual and hired labour is paid in cash.

4.3.3 Cash supply

Traditional farming does not require considerable amounts of cash. As the involvement of the farm in a market economy increases and more and more purchased inputs such as improved seeds, fertilizers, pesticides and the like, are used, the cash requirement for farm expenditure rises. This will be the case in Way Seputih when improved technology is adopted after irrigation water is made available.

Internal sources of finance and money borrowed from outside sources form the cash supply for farm operations. In the present situation where most of the settlers' standard of living is a bare minimum and the farm income is very small indeed - as discussed in section 3.2.2 - the farmer's own cash is very limited. Any farming operations are carried out in traditional ways in which cash expenditure is minimal.

The B.R.I. (Indonesian People's Bank) provides credit for crop intensification in the context of the Bimas program. Since 1965 this has been mainly confined to rice growing and has also been limited to the well irrigated sawah area but some funds are now being provided for maize (Bimas Jagung) and poultry (Bimas Ayam). The relatively cheap Bimas credit (12 per cent per annum) is very important for Way Seputih farmers because the intensification program is still in the initial stages and low cost credit will be an incentive to adopt new technology.

The gross margin concept is used in the present analysis. The cash supply for the expenditure of crops/livestock during the year is divided into that for the wet season (CASWET) and that for the dry season (CADRY). Cash expenditures financed by the cash supplies are the 'variable costs', and include the purchase of seeds, fertilizers, pesticides and payment for hired labour. Expenditures for land tax, water charge (assumed), interest on capital borrowed, and depreciation of farm fixed capital assets used in the process of production, are treated as 'common costs' and are used when calculating net farm income.

The present analysis is of a static nature and does not take into account possible capital transfers between periods or seasons. The total available cash supply in the wet season is assumed to be available for the dry season, as is the case with credit for production which has to be repaid after the harvest (plus interest) but which can be borrowed again in full for the next season.

4.3.4 Other constraints

There are some socio-economic constraints worth mentioning. For subsistence farmers, the first consideration is to grow some minimum crops to satisfy family food requirements. However, it is inappropriate to assume complete subsistence for Way Seputih farmers. The food crops they grow enter the market as a surplus above their consumption needs as well as, and primarily, to meet urgent money requirements. Very often the farmers have to 'repurchase' these commodities for their consumption.

For this reason, no predetermined minimum level of food crops will be assigned to the matrix.

The maximum levels of some crops, for instance because of limited market demand, are not specified, due primarily to a lack of sufficient data on the nature of that demand.

4.4 Activities Included

Based on available information and the analysis discussed above, 25 activities are included in the matrix. These consist of 18 annual crops, 2 perennial cash crops, 1 livestock enterprise of poultry, and four of labour hiring. Crop enterprises applying different levels of technology, and thus having different input-output relationships, are treated as separate activities. For example, rice growing in the wet season sawah using traditional methods and rice growing with improved methods are considered as two distinct activities. In fact, there are still many possible alternative activities that can be included in the matrix, but the inclusion of the above activities are regarded as sufficient for the present analysis.

Each activity has particular input-output coefficients which denote the unit amounts of resources required to produce one unit of the activity concerned. The value of these coefficients are estimates of the average values based on the limited data discussed in Chapter 3. A coefficient has a minus sign when it contributes to any resource supply and a plus sign when it consumes any of the resources. Zero coefficients denote no relation between the activity and the resources concerned.

Each activity also has a certain gross margin (GM) calculated on a per unit of activity basis. The gross margin is the difference between the value of output and the variable cost expenditures to produce that output. In this analysis, costs exclude the common costs which are used for the operation of the farm as a whole. The gross margin concept treats the farm as a whole entity and farm income is calculated as the total gross margin of the entire enterprise combination (TGM) minus the common costs. Since the common costs are unique (constant) for a certain set of resource supplies, formulating the objective to maximise the TGM maximises farm income at the same time.

The periods during which each activity takes place - in relation to the defined periods of the year presented in Figure 4.1 - are shown in Figure 4.2. Table 4.2 shows the labour requirements of each activity in each period. The cash expenditure and the gross margins, respectively, are presented in Tables 4.3 and 4.4.

4.5 The Input-Output Matrix

The input-output matrix has dimensions of 17 x 25 and is attached in Appendix C. The resource supplies of the matrix refer to the base situation. For the parametric programming analysis, variations are ascribed to the resource supplies only, especially those which are found to be binding at the base situation. Tobacco is taken as an example in examining the stability of an optimum solution with respect to the gross margin. Although input-output coefficients do vary between farms, the variations are not examined in the analysis. The results of analysis are discussed in the following two chapters.

FIGURE 4.2

THE PERIODS OF CROP GROWTH/LIVESTOCK REARING

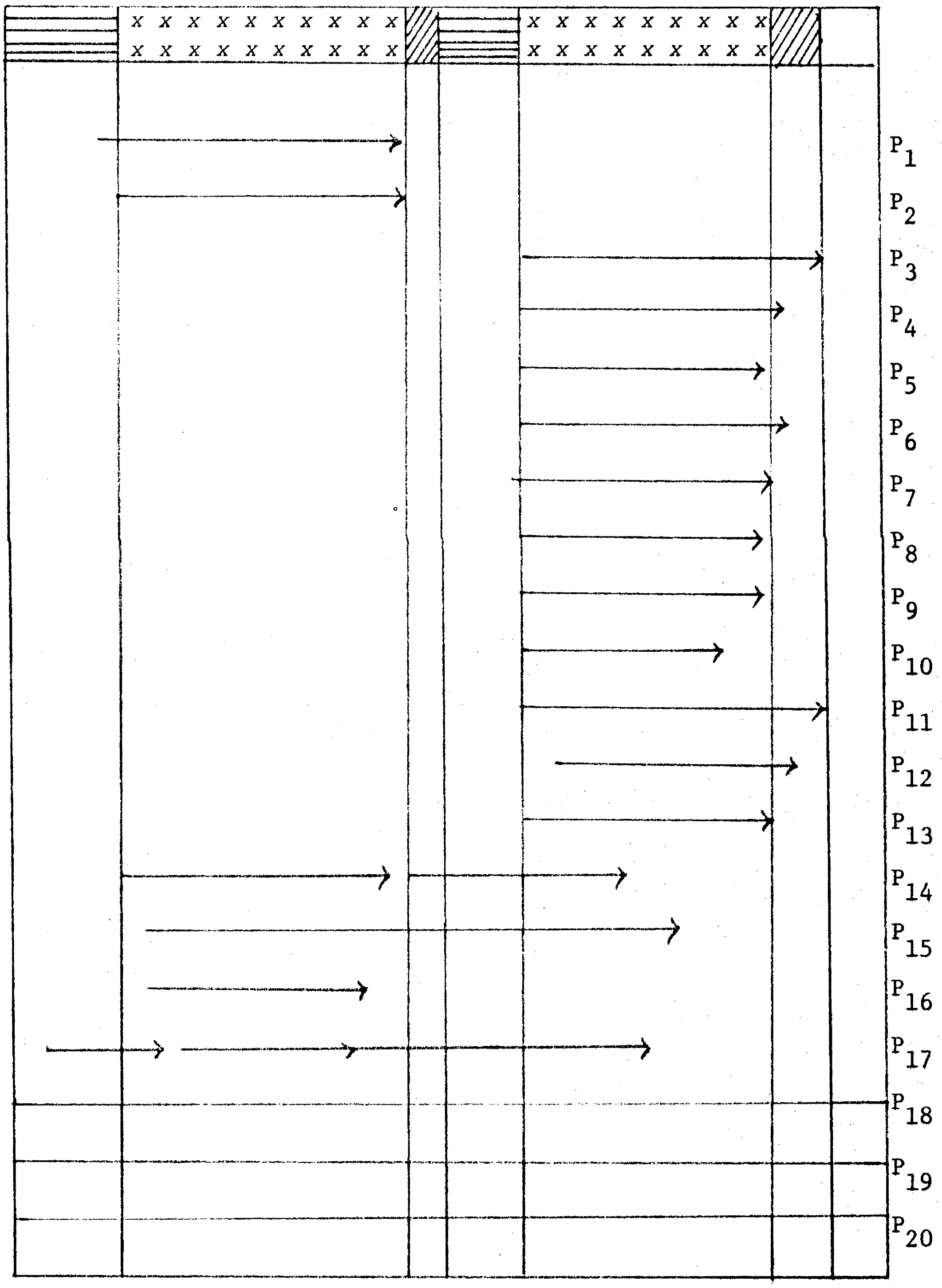


TABLE 4.2

LABOUR REQUIREMENTS OF VARIOUS CROPS AND LIVESTOCK PER UNIT ACTIVITY*

Code	Activity** Name	Labour Requirement per Period (man hours) I	II	III	IV	V	VI	VII	Total
P1	W.S. Unimproved Rice	91.2	10.5	27.5	-	-	-	-	129.2
P2	W.S. Improved Rice	126.4	24.5	52.5	-	-	-	-	203.4
P3	D.S. Unimproved Rice	-	-	-	80.6	9.0	1.5	27.5	118.6
P4	D.S. Improved Rice	-	-	-	98.4	24.5	52.5	-	175.4
P5	D.S. Unimproved Maize	-	-	-	66.5	9.1	5.6	-	81.2
P6	D.S. Imprived Maize	-	-	-	92.4	18.9	14.0	-	125.3
P7	D.S. Unimproved Soybean	-	-	-	19.6	7.7	17.5	-	44.8
P8	D.S. Improved Soybean	-	-	-	87.5	14.7	24.5	-	126.7
P9	D.S. Ground Nut	-	-	-	88.2	15.4	28.0	-	131.6
P10	D.S. Mungo Bean	-	-	-	-	123.9	-	-	123.9
P11	D.S. Sweet Potato	-	-	-	91.0	10.5	28.0	-	129.5
P12	D.S. Tobacco	-	-	-	129.5	91.5	10.0	-	123.1
P13	D.S. Red Spanish Pepper	-	-	-	78.2	51.3	13.1	-	142.6
P14	Sorghum	-	125.3	21.0	7.0	17.5	-	-	170.8
P15	Cassava	-	111.3	-	-	45.5	-	-	156.8
P16	Soybean	-	133.0	-	-	-	-	-	133.0
P17	Mixed Crop	46.0	94.5	-	-	33.5	30.0	50.0	244.0
P18	Mungo Bean	-	130.2	-	-	-	-	-	130.2
P19	Rubber	9.8	28.2	3.6	9.0	25.2	5.6	4.2	85.6
P20	Coconut	-	7.7	-	-	6.3	-	4.9	18.9
P21	Poultry	98.0	238.0	28.0	32.0	147.0	42.0	31.5	638.0

Note: * All crops are in da, poultry in 100 birds.

** W.S. indicates wet season sawah land.
D.S. indicates dry season sawah land.
P14 - P20 are in the non-sawah land.

TABLE 4.3

CASH EXPENDITURES OF VARIOUS CROPS AND LIVESTOCK PER UNIT ACTIVITY*

Code	Activity** Name	Specified Costs: Seed	Fertilizers	Pesticides	Others	Total
P1	W.S. Unimproved Rice	87.5	-	75	17.5	180
P2	W.S. Improved Rice	90.0	750.0	150	10.0	1,000
P3	D.S. Unimproved Rice	87.5	-	75	17.5	180
P4	D.S. Improved Rice	90.0	750.0	150	10.0	1,000
P5	D.S. Unimproved Maize	37.5	-	75	12.5	125
P6	D.S. Improved Maize	50.0	825.0	150	10.0	1,035
P7	D.S. Unimproved Soybean	143.0	-	75	7.0	225
P8	D.S. Improved Soybean	160.0	1,190.0	75	5.0	1,430
P9	D.S. Ground Nut	300.0	1,190.0	75	5.0	1,670
P10	D.S. Mungo Bean	127.5	1,190.0	75	7.5	1,400
P11	D.S. Sweet Potato	200.0	-	75	25.0	300
P12	D.S. Tobacco	500.0	1,075.0	150	525.0	2,350
P13	D.S. Red Spanish Pepper	500.0	1,075.0	150	10.0	1,735
P14	Sorghum	20.0	1,650.0	150	5.0	1,825
P15	Cassava	200.0	970.0	150	5.0	1,325
P16	Soybean	160.0	1,190.0	75	5.0	1,430
P17	Mixed Crop	225.0	-	15	-	240
P18	Mungo Bean	127.5	1,190.0	75	7.5	1,400
P19	Rubber	-	750.0	117.5	32.5	900
P20	Coconut	-	1,003.5	175.0	21.5	1,200
P21	Poultry	-	-	-	-	148,050***

Note: For * and ** see Table 4.2

*** For feed, vaccines, etc., About one week's stock (Rp.3,000) is used for the i/o coefficients.

TABLE 4.4

GROSS MARGIN OF VARIOUS CROPS AND LIVESTOCK
PER UNIT ACTIVITY*

Code	Activity** Name	Yield (kg)	Price (Rp/kg)	Gross Return (Rp)	Cash Expenditures (Rp)	Gross Margin (Rp)
P1	W.S. Unimproved Rice	210	29	6,090	180	5,910
P2	W.S. Improved Rice	450	29	13,050	1,000	12,050
P3	D.S. Unimproved Rice	200	29	5,800	180	5,620
P4	D.S. Improved Rice	450	29	13,050	1,000	12,050
P5	D.S. Unimproved Maize	100	20	2,000	125	1,875
P6	D.S. Improved Maize	400	20	8,000	1,035	6,965
P7	D.S. Unimproved Soybean	70	55	3,850	225	3,625
P8	D.S. Improved Soybean	120	55	6,600	1,430	5,170
P9	D.S. Ground nut	120	85	10,200	1,670	8,530
P10	D.S. Mungo Bean	100	70	7,000	1,400	5,600
P11	D.S. Sweet Potato	1,000	11	11,000	300	10,700
P12	D.S. Tobacco	78	350	27,250	2,350	24,900
P13	D.S. Red Spanish Pepper	150	125	18,750	1,735	17,015
P14	Sorghum	600	15	9,000	1,825	7,175
P15	Cassava	830	12	9,960	1,325	8,635
P16	Soybean	100	85	5,500	1,430	4,070
P17	Mixed Crop***	-	-	8,370	240	8,130
P18	Mungo Bean	90	70	5,600	1,400	4,200
P19	Rubber	100	60	6,000	900	5,100
P20	Coconut	720	10	7,200	1,200	6,000
P21	Poultry	-	-	159,000****	148,850	10,150

Note: For * and ** see notes on Table 4.2.

*** Rice: 90kg at Rp.29 = Rp.2,610

Maize: 39kg at Rp.20 = Rp. 780

Cassava: 415kg at Rp.12 = Rp.4,980

Rp.8,370

**** Eggs and culls.

CHAPTER 5

LINEAR PROGRAMMING SOLUTIONS

The initial linear programming solution refers to the base situation where production is determined by the existing resources supplies and technology. This optimal solution is analysed and compared with current farming performance. Based on the information acquired from this solution, especially regarding the relative scarcity of resources, an attempt is made to investigate the effects of relaxing some of the binding constraints. This is analysed mainly in regard to its effects towards improving current farming performance, resource productivity and, in particular, farm income.

5.1 LP Solution to the Base Situation

The linear programming solution to the current sets of resource supplies is interesting. The activities included in the plan and the binding resource constraints facing the farm have a close similarity with the present state of the farming as reported in the IPB Social-Economic Survey. However, the amount of land cultivated, the labour used, and the income gained, are considerably greater.

The activities included in the plan are presented in Table 5.1. Table 5.2 shows the resources used and the shadow prices of these resources. Table 5.3 presents the marginal value products (MVPs) of the excluded activities.

TABLE 5.1

OPTIMAL SOLUTION OF THE BASE SITUATION

Type of Land	Activity Code	Activity Description	Level (da)	Gross Margin (Rp)	Crop Intensity
Sawah	P1	W.S. unimproved rice	7.18	42,434	
	P7	D.S. unimproved soybean	3.45	12,506	
	P11	D.S. sweet potatoes	5.50	58,850	
	P13	D.S. red spanish pepper	1.05	17,865	
		Sub-total sawah	17.18	131,655	1.72
Non-sawah	P15	Monoculture cassava	2.95	25,473	
	P17	Mixed crop	4.02	32,682	
		Sub-total non-sawah	6.97	58,155	0.99
		TOTAL	24.15	189,810	1.42

Note: For the present sawah farmer, the average figures are:

Sawah: W.S. unimproved rice = 6.0 da
D.S. unimproved rice = 6.0 da

Non-sawah: Cassava/mixed crop = 2.4 da

TABLE 5.2

RESOURCE USE IN THE OPTIMAL SOLUTION AND SHADOW PRICES OF RESOURCES

RESOURCE			Supply	Usage	Shadow Prices
Code	Description	Unit			
WIRSL	W.S. sawah land	da	10	7.18	-
DIRSL	D.S. sawah land	da	10	10.00	613
DIRWAT	D.S. irrigation water	unit	2.50	1.72	-
SANOL	Non-sawah land	da	7	6.97	-
PEAKW1	W.S. first peak labour	man hrs	840	840	65.50
ORDW1	W.S. slack labour	"	1,139	783	-
PEAKW2	W.S. second peak labour	"	240	197.50	-
PEAKD1	D.S. first peak labour	"	600	600	93.60
ORDD1	D.S. first slack labour	"	1,005	407	-
PEAKD2	D.S. second peak labour	"	360	348.50	-
ORDD2	D.S. second slack labour	"	201	201	72.90
HIPW1	W.S. first hired labour	"	75	-	-
HIPW2	W.S. second hired labour	"	120	-	-
HIPD1	D.S. first hired labour	"	50	50	0.06
HIPD2	D.S. second hired labour	"	240	-	-
CASWET	W.S. cash supply	rupiah	5,000	5,000	6.52
CADRY	D.S. cash supply	"	5,000	5,000	5.24

Note: W.S. = Wet Season
d.s. = Dry Season

TABLE 5.3

THE MARGINAL VALUE PRODUCTS OF EXCLUDED ACTIVITIES IN THE OPTIMAL SOLUTION

A C T I V I T I E S		MVP
Code	Description	(Rp/da)
P2	W.S. improved rice	2,500
P3	D.S. unimproved rice	5,480
P4	D.S. improved rice	3,010
P5	D.S. unimproved maize	5,620
P6	D.S. improved maize	7,710
P8	D.S. improved soybean	11,100
P9	D.S. ground nut	9,080
P10	D.S. mungo bean	2,340
P12	D.S. tobacco	136
P14	Sorghum	4,220
P16	Soybean	5,250
P18	Mungo bean	4,920
P19	Rubber	1,900
P20	Coconut	1,280
P21	Poultry	3,280

Note: W.S. = Wet Season
D.S. = Dry Season

The activities included represent a state of 'poor capital pattern' (pola kurang modal). The unimproved wet season rice in sawah, the mixed crop rice-maize-cassava, and monoculture cassava in the dryland are still dominant in the plan. The plan also shows the feasibility and relative profitability of these crops considering the present resource supplies and constraints.

At present, more than two-thirds of the farmers cultivating sawah are planting unimproved rice. In the dryland, the mixed crop is the most profitable and is cultivated by more than half the farmers in Way Seputih. Monoculture cassava is the next most profitable crop in the dry-land, after the mixed crop. Evidently, in Way Seputih, cassava is a very important crop at present, both as a food supply and as a source of income. It also has a good export market.

In the optimal linear programming solution, however, no dry season rice (gadu) appears. In the dry season sawah, soybean, sweet potatoes and red spanish pepper come into the plan; it is more profitable to introduce these crops in the dry season than to grow rice.

The abovementioned diversification of secondary crops has a further advantage over current practice. Diversification makes the water shortage in the dry season less serious. The experience with similar gravitational irrigation in Southern Lampung shows that lack of water in the dry season sawah has a very bad effect on crop production. In the case of Way Seputih, only twenty-five per cent of the total sawah can be sufficiently irrigated for rice crops. Without proper regulation of water use in this season, especially when farmers are allowed to grow 'gadu' without restriction, water shortages occur and a higher risk of production failure is present.

By adopting diversification of secondary crops, all of the sawah land in the dry season can be planted with various crops other than rice if an assured water supply exists. Indeed, this solution means that some water will be unused, namely about .78 unit from the average farm. Seven per cent of the farmers in the area can thus be allotted sufficient water for 'gadu' and can grow it if they prefer to, provided they are satisfied with a lower income. Forcing the inclusion of 'gadu' in the farm will reduce the total gross margin by Rp.5,480 for one da of unimproved rice and Rp.3,010 in the case of improved rice (Table 5.3).

It may be argued that double-cropping in rice is necessary to achieve self-sufficiency in rice. This may be true at the national level, or even at the provincial level but is true neither in the area of Way Seputih nor at the farmer's level. To meet the level of rice consumption of 120 kg/cap./annum, an average farmer needs at most, one-third of his sawah in the wet season planted with improved rice, or two-thirds if planted with unimproved rice.

Good water management is very important if the best use is to be made of the limited available water supply with the present cropping pattern. Water charges might be introduced to economise the water use, instead of providing water free as is common now. Still better management is needed to meet the proper quantity and timing required for individual crops when crop diversification is adopted.

The levels of activities included in the optimal solution are of interest. The whole sawah of 10 da in the dry season is occupied by 3.45 da of unimproved soybean, 5.50 da of sweet potatoes and 1.05 da of red spanish pepper. These are cultivated with the aid of 50 man hours hired labour. The fact that the red spanish pepper is included at a low level even though it has a higher gross margin than the other two (Table 4.4) is explained by the larger amount of capital and labour required to grow this crop (Tables 4.2 and 4.3). With respect to the present situation, it is capital and labour that are constraining, not land. Of the 10 da sawah in the wet season, only 7.18 da is planted with rice (unimproved), leaving the other 2.82 da of land idle. The binding constraint here is the labour for land preparation. The 75 man hours available through hiring are not used due to the shortage of capital. The above amount of cultivated sawah corresponds to the common situation wherein the capacity of sawah cultivation using the traditional manual hoeing technique is limited to around one 'bau'. 'Bahu' or 'bau' means shoulders or hands, and one 'bau' of the old measure of land size in Java is 7.09 da.

The crop combination and levels as shown in the above linear programming solution mean greater land and labour use as well as an increased income, compared with the present situation. At present, the average land cultivated is only 8.1 da, being 8.4 da for farmers with sawah plus dry-land and 7.9 da for dry-land farmers. The optimal solution gives a figure of 14.2 da in the wet season and 17.0 da in the dry season, or 1.7 to 2.1 times as large as in the existing situation. The cropping intensity in the linear programming solution is 1.42 (Table 5.1).

The optimal total labour use is 3.427 man hours of which 3,377 man hours is family labour, compared with the present labour use of 1.523 man hours, of which 1.190 man hours is family labour. This means that labour use increases by 2.8 times, an improvement on the present underemployment situation which prevails in the study area.

At present, the low labour input in farming and low farm income are compensated for by off-farm employment. Here, 'off-farm' means away from the farmer's own farm, because it usually also involves work on a neighbour's farm. According to the Social Economic Survey, 'off-farm' work involved 120 man days (720 man hours) for the sawah farmers and 108 man days (648 man hours) for the dry-land farmers in 1969/70. Thus it is very important because it accounts for 41.4 per cent to 56.0 per cent of their total labour use and provides 63.4 per cent to 67.9 per cent of their total family income. The question then is whether the greater labour use in the optimal solution provides an income comparable to the ones presently gained.

A comparison of income with that of the present sawah farmer is attempted. However, no simple, direct comparison can be made, because different sets of prices have been used and, as well, the duration of one day's work differs between the Survey and this analysis. For the purpose of comparison, however, all of the labour use is transformed into man hours and the physical products are valued at 1972/73 prices. The assumptions and calculations are presented in Appendix D. It is shown that the farm income increases from Rp.38,600 to Rp.111,000 or by nearly 2.5 times. The farm income in the optimal solution also exceeds the present total family income of Rp.80,5000. The rate of income per man hour work in the new farm plan is higher than that in the present farm income and is only slightly lower than that for the family income. The figures are Rp.32.90, Rp.3170 and Rp.39.10 respectively. However, off-farm work is not always available. The income per capita is US$35 in the new plan (from the farm only) compared with the existing US$29.40 (total).

In the optimal solution, about 23 per cent of the available supply of family labour remains unused in the process of production. This amount of time can be engaged in off-farm employment and various communal works ('gotong-royong') to build/repair rural roads, irrigation ditches, etc. It can also be spent for various minor jobs on the farm or, otherwise, to enjoy leisure.

5.2 The Parametric Solutions

Having obtained the maximum possible income at the base situation, which is a still unsatisfactory US$35/cap./annum, a question might be put forward: Is there any possible way of improving the present situation?

The dual linear programming solution provides information on some economic opportunities. The shadow prices of the available resources, as shown in Table 5.2 above, show the relative scarcity of the resources concerned. Some of these resources, like working capital and power for land preparation, can be made available more readily than others. However, the amount of land available for farming in the Way Seputih area cannot be increased. Parametric analysis to investigate the effects of increasing the availability of resources of the first type can provide information on some practicable ways open to improve the present condition of farmers. In the case of the second type of resources, such as land, it serves as guidance for future land settlements.

Improving technology, introducing other innovations, or organising better marketing and the like, are also means of improving the existing economic situation, but are beyond the scope of this analysis. The effects of varying the availability of working capital, peak season labour, and non-sawah land, are discussed below.

5.2.1 Working capital -

Working capital for both the wet season and dry season farm operations shows very high shadow prices, i.e., 6.52 and 5.24 respectively. Increasing the available capital by Rp.1.0 in the wet season under existing conditions will step up the total gross margin by Rp.6.52. If this Rp.1.0 is also available for the dry season - a one year loan for example - it will further increase the total gross margin by Rp.5.24. Thus increases in working capital are highly rewarding. The values of shadow prices will, however, as will be seen later, change and eventually decrease as the available capital increases. This change is not continuous, but follows a stepped-down course having stable values within certain ranges of capital supply. Table 5.4 illustrates this phenomena.

As working capital is progressively increased from Rp.5,000 (the present assumption) to Rp.18,000, the total gross margin increases at a decreasing rate (column 3) showing diminishing returns to capital as other inputs become limiting. At Rp.16,534 capital becomes idle for the wet season, while for the dry season the level is Rp.17,765. Beyond these points, that is, after the capital ceases to be constraining, the shadow prices are naturally zero. With other resources constant, the value of the total gross margin remains unchanged at Rp.289,000 after these points. Any further increases in capital are not worthwhile. Indeed, any such increases would actually reduce the income by the amount of interest charged on the additional capital.

The above working capital requirement can be compared with the present possible capital availability. Internal sources of capital in the existing situation cannot be expected to exceed the assumed level of Rp.5,000. The Social Economic Survey reported that the present farm income is only about a quarter to one-third of the basic consumption requirement. The former is for any dry-land farmers who have had their dry-land converted into sawah. The latter is for farmers who have started with sawah cultivation. Additional income at the moment comes from off-farm employment. In such circumstances, and where there is no cheaper credit, farmers usually fall into the grip of usury or the 'ijon system', where a 10 per cent per month interest rate is common.

The establishment of sawah opens the possibility of farmers obtaining credit by joining the Bimas Program. This program provides relatively cheap credit, 12 per cent a year, compared with at least

TABLE 5.4

THE EFFECT ON TOTAL GROSS MARGIN, SHADOW PRICES OF CAPITAL AND OPTIMAL CROP COMBINATION OF INCREASING WORKING CAPITAL

Working Capital (Rp)	TGM (Rp)	Increase in TGM (Rp)	Shadow Prices of Capital*		CROP COMBINATION (da)								
			Wet Season	Dry Season	Unimproved W.S. Rice	Improved W.S. Rice	Unimproved D.S. Soybean	D.S. Mungo Bean	D.S. Sweet Potatoes	Tobacco	Red Spanish Pepper	Cassava	Mixed Crop
5,000	189,000	-	6.52	5.24	7.18	-	3.45	-	5.50	-	1.05	2.95	4.02
7,000	208,000	19,000	3.96	5.24	4.40	2.01	3.21	-	4.36	-	2.43	2.98	4.02
9,000	225,000	17,000	3.52	5.24	1.56	4.06	2.96	-	3.23	-	3.81	2.98	4.02
11,000	242,000	17,000	2.98	5.24	-	5.41	2.71	-	2.10	-	5.19	3.60	3.40
13,000	259,000	17,000	2.98	5.24	-	5.91	2.46	-	0.96	-	6.57	4.98	2.02
15,000	275,000	16,000	2.98	3.84	-	6.41	2.01	0.17	-	-	7.81	6.36	0.63
16,000	282,000	7,000	2.96	3.84	-	6.67	1.22	0.77	-	-	8.01	7.00	-
17,000	287,000	5,000	0(467)	3.84	-	6.86	0.42	1.37	-	-	8.21	7.00	-
18,000	289,000	2,000	0(1467)	0(236)	-	6.86	-	2.07	-	0.58	7.35	7.00	-
19,000	289,000	-	0(2467)	0(1236)	-	6.86	-	2.07	-	0.58	7.35	7.00	-

Note: * The values in brackets are the amounts of idle capital in rupiah.

30 per cent for ordinary agricultural credit, which is very hard to get in any case. The Bimas provides credit up to Rp.20,000 per hectare in the case of New Bimas, that is Bimas using new improved rice varieties, such as PB-5 or Pelita I/1. The crop activity of improved rice used in this analysis is assumed to be of this kind.

What do the linear programming solutions reveal of the optimum crop combinations at this level of available capital? The results can be seen in Table 5.4 above which shows the optimal crop combinations at different levels of working capital.

At the maximum level of capital availability the level of improved rice is 6.86 da, making a farmer eligible to get Bimas credit up to Rp.13,600. The balance of Rp.4,400 can be sought from other external sources. The farmer will be eligible also for Palawija Bimas credit because cassava is also grown at 7.0 da. However, if the present plan were adopted, he would get total gross margin of Rp.289,000 or an income of not less than Rp.160,000.* Thus, his income would have been increased by Rp.79,500 compared with the present Rp.80,500. In fact, the marginal propensity to consume (MPC) is still high for the low income farmer. But, suppose he had an MPC of 0.9, he would still be able to set aside Rp.7,950 to improve his capital supply in the next season, i.e., an internal source of finance would have been generated.

The analysis suggests that, in the present situation, capital is a key factor for the improvement of farmers' income and the adoption of new improved cultural practices. With a working capital of less than Rp.11,000 the unimproved rice still appears in the optimal solution. The same is true for other crops. In general, the less working capital available, the more the unimproved crops dominate in the optimal solution, and the less is the value of the total gross margin and, thus, income.

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* See Appendix D for Assumptions and Calculations. For this case, income = 2/3 x 289,000 - 25,000 = 167,600.

The analysis also indicates that the labour requirements increase as the supply of capital increases, as shown in Table 5.5.

TABLE 5.5

THE EFFECT OF DIFFERENT WORKING CAPITAL ON THE AMOUNT OF LABOUR USE

Working Capital (Rp)	Labour Requirement (man hours)		
	Family	Hired	Total
5,000	3,377	50	3,427
7,000	3,471	50	3,521
9,000	3,544	66	3,610
11,000	3,568	94	3,662
13,000	3,548	120	3,669
15,000	3,544	147	3,691
16,000	3,584	164	3,748
17,000	3,654	197	3,851
18,000	3,734	197	3,931
19,000	3,734	197	3,931

5.2.2 <u>Peak season labour</u> -

It has been noted that only 7.18 da out of the available one hectare of sawah can be cultivated using the present technology of manual hoeing. Available labour for land preparation is the binding constraint at this stage. With the increase in working capital and the adoption of improved practices which require slightly more labour, the level is only 6.86 da. Even if more labour can be made available for land preparation by assuming the introduction of more draught cattle, this level cannot be increased further. In this situation the supply of harvesting labour becomes the binding constraint.

Table 5.6 presents the results of introducing more draught cattle. Initially it is assumed that the available cattle in the community can be used to help in the work of land preparation. The assumption is that one pair of bullocks is shared by twelve farms and this pair is capable of providing the equivalent of 75 man hours in the wet season and 50 man hours in the dry season. By increasing the available draught cattle up to one pair for every two farms,* the total gross margin increases up to Rp.323,000. The improved total gross margin is not due to the greater amount of wet weason rice cultivated in sawah, however, but is due to the shift in the composition of the secondary crops towards the more labour intensive crops. The wet season rice remains at the level of 6.86 da. Only by increasing the available man hours for harvesting, as shown in Table 5.7, can the whole one hectare sawah be operated. This is achieved with additional labour of 285 man - sickle - hours. At this level, the additional labour for land preparation is 424 man hours, slightly below the available one pair of draught cattle to two farm families.

Both human and animal power have been expressed in man hour equivalents to facilitate comparison. For example, the 424 man hours of land preparation could be in the form and amount of the abovementioned draught cattle; or in the form of one hand tractor for 10 to 15 farms, or as manual hoeing which might be offered by our spontaneous migrants or unemployed urban workers.

Similarly, harvesting labour is expressed in man hours of sickle harvesting. When the traditional 'ani-ani' is used, the required labour needs to be increased at least threefold. It is probable that the 'ani-ani' method will change gradually as the circumstances require. In Malaysia, for example, in Tanjong Karang irrigated rice area, combine harvesters have been used to overcome the labour shortage for harvest. In this area, 60 per cent of the rice holdings are between four to six acres or 16.3 to to 24.4 da. (Bhati, 1971).

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* It should be noted that with more cattle raised, the available land for pasture needs to be considered.

TABLE 5.6

THE EFFECT ON THE OPTIMAL SOLUTION OF INTRODUCING DRAUGHT CATTLE POWER

Ratio of Draught Cattle to Farm	Total Gross Margin (Rp)	Increase* in TGM (Rp)	CROP COMBINATION (da)				
			W.S. Improved Rice	D.S. Mungo Bean	Tobacco	Red Spanish Pepper	Monoculture Cassava
1:12	289,000	-	6.86	2.1	0.6	7.3	7.0
2:12	296,000	7,000	6.86	1.8	1.1	7.1	7.0
3:12	303,000	7,000	6.86	1.5	1.6	6.9	7.0
4:12	310,000	7,000	6.86	1.2	2.2	6.3	7.0
5:12	317,000	7.000	6.86	0.9	2.7	6.4	7.0
6:12	323,000	6,000	6.86	0.6	3.2	6.2	7.0

* The cost of hiring 1/12 pair of draught cattle for land preparation in the wet season is Rp.1,875.

TABLE 5.7

THE EFFECT OF AVAILABLE HIRED LABOUR FOR HARVESTING ON THE AMOUNT OF WET SEASON RICE GROWN AND ON THE TGM

Harvest Labour (man hrs)	Wet Season* Rice (da)	TGM (Rp)	Increase** in TGM (Rp)
60	5.71	312,000	-
120	6.86	323,000	11,000
180	8.00	333,000	10,000
240	9.14	343,000	10,000
300	10.00 (15)	350,000	7,000
360	10.00 (75)	350,000	-

Note: * The number in brackets shows the unused harvesting labour.

** Cf. The cost of hiring additional 60 man hours for rice harvesting is Rp.2,100.

The old settlements on sawah also suffer from a situation of labour shortage. The spontaneous migrants come to the area mostly at the harvest time. There are mutual advantages for the old settlers who need additional labour to get all of the crop harvested and the newcomers who can earn some income to overcome the difficulties of the first months. The new spontaneous migrants generally offer to work for the older settlers for longer periods. If the new settlers are not allotted land of their own, they will be overcrowded, thus lessening the opportunity of both old and new settlers to make a satisfactory living. If the current level of technology remains unchanged, this grim situation could eventuate in Way Seputih.

5.2.3 The land resource -

At present, there has been no reserved land in Way Seputih to be used to increase the size of holdings of the settlers. For designing future settlements, however, an analysis of the effect of different sizes of farmland allocated to the settlers might yield some valuable information. This kind of analysis might also be useful for other ongoing settlements in planning for further settlers to come and be allocated the traditional two hectares of land.

In this analysis, it is non-sawah land and not the sawah which is investigated. Some of the reasons for this may be deduced from the foregoing analysis. With the existing techniques of land preparation and harvesting it is already difficult to utilize fully the one hectare of sawah allocated. Establishing irrigated sawah is also very expensive. Furthermore, the land potantially suitable for irrigated sawah in the outer islands is much more limited than that suitable for non-sawah cultivation.

The effects of increasing non-sawah land up to 50 da are presented in Table 5.8. As the available non-sawah land increases up to 47.2 da, the total gross margin also increases, but at a decreasing rate. Beyond the 47.2 da level, the plan does not change. At this level, the value of the total gross margin reaches Rp.463,000.

The maximum cultivable non-sawah land is 47.2 da, of which 41.0 da is occupied by coconut. No rubber enters the optimum solutions. It is also interesting to note that coconut begins entering the solution only at levels of non-sawah land above 8.0 da. Beyond this level, all of the additional land is taken up by coconut and some of the annual crops are also replaced by coconut. This means that annual crops in the non-sawah land are more profitable than coconut only when there is insufficient land available. When more land is allocated to the settlers, it is profitable for them to grow coconut.

The above situation also applies to other perennial crops such as rubber, which is also investigated in this analysis. If rubber is planted instead of coconut it is profitable only when the available non-sawah land is greater than 10.0 da. The maximum level of rubber cultivated, however, is smaller. The maximum manageable area for rubber is only 13.1 da, due primarily to the more labour intensive nature of rubber compared with coconut. This maximum level is reached when 22.5 da of non-sawah land is allocated. But when only 5.0 da of sawah is available instead of one hectare, 30.3 da of rubber can be managed. The level is 47.7 when no sawah land is available.

For rubber, the labour use pattern used in this analysis has been slightly modified by allowing the maximum hours of work per week in the non-peak periods of the present model to reach thirty-six instead of thirty. The total labour required is greater for rubber than for coconut

TABLE 5.8

THE EFFECT ON TGM AND OPTIMAL CROP COMBINATION OF ALLOCATING DIFFERENT AREAS OF NON-SAWAH LAND

Non-sawah Land (da)	TGM (Rp)	Increase in TGM (Rp)	Crops in Non-sawah Land (da)		Uncropped
			Perennial[1]	Annuals[2]	
1	2	3	4	5	6
5.0	333,000	-	-	5.00	-
10.0	368,000	35,000	2.04	7.96	-
15.0	393,000	25,000	7.29	7.71	-
20.0	417,000	24,000	13,00	7.00	-
25.0	438,000	21,000	17.60	7.40	-
30.0	445,000	7,000	22.80	7.20	-
35.0	451,000	6,000	28.10	6.90	-
40.0	456,000	5,000	33.40	6.60	-
45.0	461,000	5,000	38.70	6.30	-
47.50	463,000	2,000	41.00	6.20	.30
50.0	463,000	-	41.00	6.20	2.80

Note: 1. The only perennial crop entering the solution is coconut.

2. The annual crops are monoculture cassava and mixed crop rice-maize-cassava.

TABLE 5.9

THE EFFECT ON TGM AND ACTIVITY COMBINATION OF ALLOCATING DIFFERENT AREAS OF NON-SAWAH LAND

(Sawah = 5da, rubber is planted instead of coconut)

Non-sawah Land (da)	TGM (Rp)	Increase in TGM (Rp)	Activity Combination* (da)					
			Rubber	Poultry**	Cassava	Sorghum	Mixed	Green Bean
1	2	3	4	5	6	7	8	9
2.5	237,000	-	-	4.06	2.5	-	-	-
5.0	250,000	13,000	-	2.89	8.0	-	-	-
7.5	263,000	13,000	-	1.78	6.77	-	.73	-
10.0	275,000	12,000	-	.76	7.10	-	2.90	-
12.5	286,000	11,000	.88	-	7.29	-	4.33	-
15.0	295,000	9,000	4.38	-	7.03	-	3.59	-
17.5	303,000	8,000	7.88	-	6.78	-	2.84	-
20.0	312,000	9,000	11.20	-	6.53	-	2.10	-
22.5	321,000	9,000	14.90	-	6.27	-	1.35	-
25.0	329,000	8,000	18.10	-	5.14	-	1.71	-
27.5	334,000	5,000	21.40	-	1.94	1.13	3.0	-
30.0	338,000	4,000	25.30	-	-	2.90	1.78	-
32.5	339,000	1,000	29.0	-	-	-	.71	2.76
35.0	335,000	-	30.3	-	-	-	-	2.99
37.5	339,000	-	30.3	-	-	-	-	2.99
40.0	339.000	-	30.3	-	-	-	-	2.99

Notes: * The crops listed are only those in the non-sawah land.

** The unit is in 100 birds.

and the total gross margin is smaller. The result in the case of 0.5 ha sawah is presented in Table 5.9.*

It is interesting to note from Table 5.9 that it is feasible and profitable to raise poultry when the available non-sawah land is less than 12.5 da. Thus, when the size of the holding is less than 1.5 ha, consisting of 0.5 ha sawah and one hectare of non-sawah, with no other reserved land to increase the size, poultry can be introduced to increase farm income. Many settlers in Southern Lampung at present possess land below the abovementioned size and, since 1973, the Government has been encouraging smallholder poultry production in the form of Bimas Ayam. For these small farmers, raising poultry enables them to improve their economic condition - with greater and more regular income generation - as well as to improve their present low protein intake.

These solutions show that coconut seems to fit better in combination with sawah. Some practical evidence from farming systems found in Malaysia and the Philippines as well as in South Sulawesi and the tidal sawah in South Kalimantan supports this analysis. The following discussion is a further analysis of the effects of allocating more non-sawah land, up to the point where coconut is dominant.

Table 5.10 shows the effect of the amount of non-sawah land on labour use. The effect on income is presented in Table 5.11.

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* In Pancawati, an Army Settlement in Way Seputih area, a plan for allocation of 0.5 ha of sawah and 3.0 ha of land was previously proposed.

TABLE 5.10

THE EFFECT ON LABOUR USE OF ALLOCATING DIFFERENT AREAS OF NON-SAWAH LAND

Non-sawah Land (da)	Labour Use (Man hours)		
	Family	Total	Per da
1	2	3	4
5.0	3,808	4,597	306
10.0	3,995	4,905	245
15.0	3,984	4,842	194
20.0	3,963	4,745	158
25.0	4,206	5,017	143
30.0	4,147	4,725	118
35.0	4,079	4,573	102
40.0	4,010	4,421	88
45.0	3,945	4,328	79
47.5	3,927	4,224	73
50.0	3,927	4,224	70

TABLE 5.11

THE EFFECT ON EXPECTED FARM INCOME OF ALLOCATING DIFFERENT AREAS OF NON-SAWAH LAND

Non-sawah Land (da)	FARM INCOME			
	Total (Rp)	Increment* (Rp)	Per Man Hour	US$/Cap./Ann
1	2	3	4	5
5.0	144,525	-	40.30	52.7
10.0	161,625	17,100	40.80	59.0
15.0	173,775	12,150	43.60	63.4
20.0	185,400	11,625	46.80	67.7
25.0	195,525	10,125	46.50	71.4
30.0	198,600	3,075	47.80	72.5
35.0	201,225	2,625	49.30	73.4
40.0	203,400	2,175	50.70	74.2
45.0	205,500	2,100	52.00	75.0
47.5	206,625	1,125	52.60	75.4
50.0	206,100	525	52.50	75.2

Note: * Cf. The present land tax for non-sawah land of 5 da is about Rp.500. The land rent for that amount is about Rp.3,750.

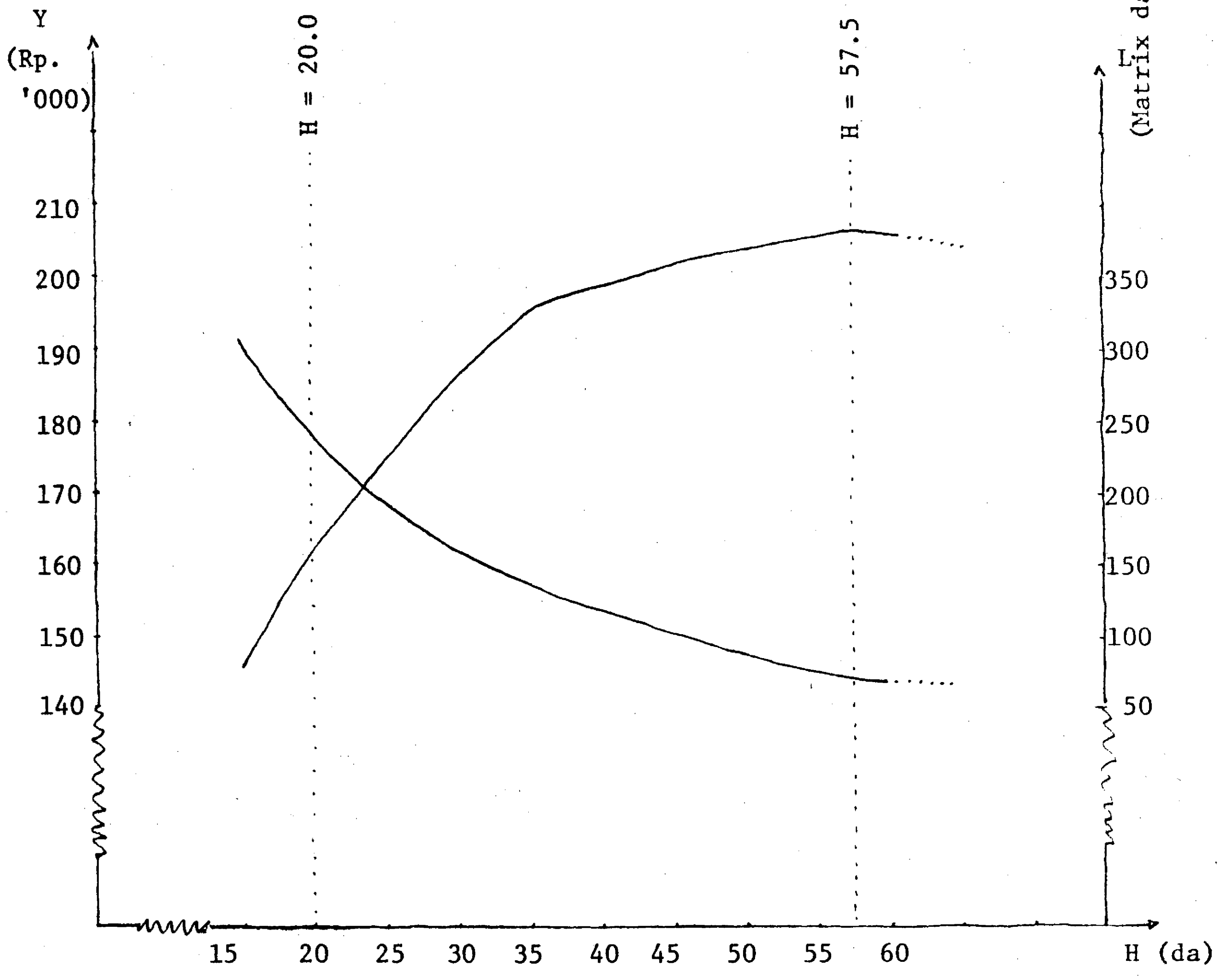
In the optimal solutions, the greatest labour use occurs around 25 da of non-sawah land. The labour use per unit of land, however, is continuously decreasing as the non-sawah land increases. This gives a picture of the labour absorption capacity of this type of farming. The capacity provides information on the number of people that can be settled in a given area of land with reasonable employment. When this information is combined with the expected income gained from different sizes of land, an appropriate land allocation for this type of farming may be estimated.

However, no exact figure can be considered as the optimum size of holding because this depends on criteria posed in the objectives of the settlement scheme. From a social (national) point of view, it might be desirable to settle as many people as possible to solve the population problem in Java. However, the more people settled in a given area of land, the lower their individual incomes. From a settler's point of view, the lower the expected income gained, the less they are attracted to the scheme. Settlers will not be attracted when the difficulty of starting life in the new area is not compensated with satisfactory gain, whether in their expectations or in comparison with other opportunity costs. From a development point of view, there must be a certain minimum income below which nothing can be set aside for personal or social savings. The stagnant condition of the farmers in the present Way Seputih after twelve to fifteen years of settlement provides a valuable lesson in this respect.

From the above two tables, (Tables 5.10 and 5.12), by supposing that the number of people settled and the expected income they gain are the criteria chosen for settlement objectives, a trade-off diagram can be drawn and is shown in Figure 5.1.

FIGURE 5.1

INCOME (Y) AND LABOUR ABSORPTION CAPACITY (L)
BY DIFFERENT SIZES OF HOLDING (H)



In the above diagram, the expected income as solved by linear programming is scaled down by 25 per cent, to make allowances for actual conditions, such as farming inefficiency and preference on sub-optimal plans* - as will be discussed later in the simulation results - including propensity to work on the part of the farmers.

From the trade-off diagram, the range of discussion can be made more specific if the objective of land settlement is more clearly defined. This issue is taken up again in Chapter 7.

Table 5.8 might also be interpreted from a different angle, namely from the point of view of stages of development. But it must be remembered that the model used in this analysis is of a static nature, a single period linear program. It does not take dynamic change over time into consideration. The distinction between two periods - wet and dry season - merely distinguishes the effect of the cycle of climatic change of the year on the production process, but not the development itself. A dynamic (multi-period) linear programming with transfer activities to link the periods is more appropriate for this purpose. This has been done, for example, by Ogunfowora (1970).

However, suppose that the price structure is maintained or all prices are moving together proportionally. As the non-sawah land is gradually added in stages to the resource supply, the optimal solutions suggest that coconut will be planted on the additional land. The coconut enterprise enters the plan when more than 8.0 da of non-sawah land is cultivated. Annual crops, which are quick yielding and are thus very important in the settler's first year of pioneering, are planted before the 8.0 da level is achieved. The income level at this stage would be twice or three times greater than the present settler's income. In the

* In the simulation solution (Chapter 6), the top twenty plans have their total gross margin between 74 and 89 per cent of the optimal solution.

subsequent stages where some coconut trees would be harvested, the income level increases further. Even with a very high marginal propensity to consume over the whole income range, it would be possible for some proportion of the income to be set aside for investment in establishing additional coconut groves, i.e. a sort of internal source of finance would have been generated. In the long run, having blocks of coconut trees in different stages of maturity means a better replacement program can be planned.

This analysis cannot answer the dynamic questions of the optimun size of the increments in blocks of trees or how many years are required for optimal replacement. It invites further rigorous study with a more appropriate model and better data.

5.3 Stability of the Plan

To inspect the stability of the optimal plan with respect to changes in the gross margin of the activities, tobacco is taken as an example. The effects of price changes in tobacco over the range of Rp.100 and Rp.500 in Rp.25 intervals are presented in Table 5.12. Tobacco does not enter the optimal solution until its price reaches Rp.300 and the plan is stable (does not change at all) over the range of tobacco price from Rp.100 up to Rp.300. Tobacco starts entering the solution at a price of Rp.325. As the price increases further, the level of tobacco included also increases up to the maximum of 5.0 da where its price is Rp.400 and beyond which the plan remains unchanged.

The level at which the tobacco price actually starts entering the solution or reaches its maximum is not analysed. The analysis, however, suggests the ranges of tobacco prices over which the optimal plan is stable or changes. Some computer packages provide programs to evaluate the stability of the plan more precisely with respect to both the objective function, the coefficients and the resource supplies.*

* For example, the MPS/360 V2-M8.

TABLE 5.12

THE EFFECT ON THE STABILITY OF THE OPTIMAL PLAN OF CHANGES IN TOBACCO PRICES

Tobacco Price	TGM	ACTIVITY COMBINATION (da)						
(Rp)	(Rp)	W.S. Improved Rice	D.S. Unimproved Soybean	D.S. Mungo Bean	Tobacco	Red Spanish Pepper	Cassava	Mixed Crop
100	289,000	6.9	1.4	0.6	-	8.0	5.2	1.8
↓								
↓								
300	289,000	6.9	1.4	0.6	-	8.0	5.2	1.8
325	289,000	6.9	0.9	1.7	1.1	6.3	5.2	1.8
350	292,000	6.9	-	1.7	1.2	6.4	5.2	1.8
375	294,000	6.9	-	1.7	1.2	6.4	5.2	1.8
400	297,000	6.9	-	1.5	5.0	-	5.2	1.8
↓								
↓								
500	334,000	6.9	-	1.5	5.0	-	5.2	1.8

CHAPTER 6

MONTE CARLO SIMULATION SOLUTIONS

In this simulation analysis, the matrix used in the linear programming model has been reduced in size to 13 x 21 by excluding the four labour hiring activities. The amounts of specified hired labour are added to the corresponding pools of peak season labour in order to include only the independent activities of crops and poultry in the selection process. The amounts of labour use, family as well as hired, are then calculated separately after the solutions are printed out.

The solutions consist of the total gross margin (TGM), the activities included, and the remaining constraints (the unused resources), in each plan. One hundred plans are printed out in descending order according to their total gross margin. An example of the top twenty plans is presented in Appendix E. This result is called Phase I.

A comparison is made with the linear programming solution of the same resource constraints in terms of their total gross margin, labour use, and activities included in the plan. The family labour use is treated as a second objective (Z_2), with total gross margin as the first (Z_1), and a multi-objective function using Z_1 and Z_2 as its variables is considered. From the information on the frequency and intervals of each activity in the top twenty plans, a multistep process of simulation is undertaken.

6.1 Phase I

Table 6.1 sets out the top twenty plans of the Phase I solution. In this step, equal weight is given to each activity for the selection process.* No particular maximum activity level is specified, except for those limits formed by the resource supply constraints. The minimum limit is one unit; otherwise the level is set to zero. A maximum of six activities per plan is specified and a thousand plans are inspected.

The top twenty plans have total gross margins within the range of 74 per cent to 89 per cent of the linear programming optimal solution. However, as shown in the table, the simulation presents a wide range of alternatives. The variations occur in the combination of activities and their levels, and the corresponding resource use. The variation is greater still if plans additional to the top twenty are considered. As can be observed in Table 6.1 above, the differences among plans are considerable in some cases but are only minor in others. For example, plans No.1 and No.3 differ by only one unit of cassava activity. An exchange between soybean (P_{16}) and mungo bean (P_{18}) occurs in plans No.5 and No.6 while plans No.7 and No.9 are more different to plan No.1, etc.

Some activities, such as gadu (P_3 and P_4) or perennials (P_{19} and P_{20}), do not appear in the top twenty but tobacco (P_{12}) appears in almost every plan. To some extent a relation exists between the frequency of appearance and the linear programming solution, especially as shown for improved wet season rice (P_2), cassava (P_{15}) and tobacco (P_{12}). An exception is for red spanish pepper (P_{13}), but as the stability analysis in the next section indicates, tobacco and red pepper are close competitors as, say, the tobacco price changes.

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* A slightly different weight has been given to activities No.17, No.20 and No.21. The cumulative weight is 100. The random numbers generated between 0 and 1, are then converted into 0 and 100 (or in percentage value).

TABLE 6.1

TWENTY TOP PLANS OF PHASE I
(With respect to TGM)

Plan No.	TGM (Rp)	Labour Use (man hrs)	ACTIVITY COMBINATION (da)																				
			P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
(LP)	289,000	3,734	-	6.86	-	-	-	-	-	-	-	2.07	-	.58	7.35	-	7	-	-	-	-	-	-
1	254,275	3,551	-	6	-	-	-	-	-	-	-	-	-	5	-	-	7	-	-	-	-	-	-
2	248,900	3,790	-	6	-	-	-	-	-	-	-	3	-	5	-	-	2	-	-	5	-	-	-
3	245,640	3,394	-	6	-	-	-	-	-	-	-	-	-	5	-	-	6	-	-	-	-	-	-
4	245,630	3,861	-	6	-	-	-	-	-	-	-	4	-	5	-	-	-	-	-	7	-	-	-
5	245,405	3,494	-	6	-	-	-	-	-	-	-	-	-	5	-	-	5	-	-	2	-	-	-
6	245,145	3,502	-	6	-	-	-	-	-	-	-	-	-	5	-	-	5	2	-	-	-	-	-
7	243,645	3,954	4	4	-	-	-	-	-	-	-	4	-	5	-	-	-	7	-	-	-	-	-
8	240,970	3,471	-	6	-	-	-	-	-	-	-	-	-	5	-	-	4	-	-	3	-	-	-
9	234,330	3,703	10	-	-	-	-	-	2	1	-	1	-	4	-	-	7	-	-	-	-	-	-
10	233,065	3,724	-	6	-	-	-	-	2	-	-	3	1	4	-	-	-	-	-	7	-	-	-

(Table 6.1 - continued)

Plan No.	TGM (Rp)	Labour Use (man hrs)	ACTIVITY COMBINATION (da)																				
			P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
11	223,325	3,465	-	6	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	7	-	-	-
12	223,230	3,486	10	-	-	-	-	-	-	-	-	-	-	5	-	-	3	1	-	3	-	-	-
13	222,970	3,370	-	6	-	-	-	-	-	-	-	-	-	5	-	-	-	2	-	5	-	-	-
14	222,935	3,494	10	-	-	-	-	-	-	-	-	-	-	5	-	-	3	4	-	-	-	-	-
15	222,320	3,484	-	6	-	-	-	-	-	-	-	-	-	5	-	-	-	7	-	-	-	-	-
16	218,720	3,551	10	-	-	-	-	-	-	-	-	-	-	4	1	-	7	-	-	-	-	-	-
17	218,400	3,976	10	-	-	-	-	-	-	1	-	5	-	4	-	-	-	5	-	2	-	-	-
18	217,095	3,717	-	6	-	-	-	-	-	-	-	4	6	-	-	-	7	-	-	-	-	-	-
19	216,120	3,285	-	6	-	-	-	-	6	-	-	-	-	4	-	-	-	-	-	6	-	-	-
20	214,945	3,374	-	6	-	-	-	2	-	-	-	-	-	3	-	2	5	-	-	-	-	-	-
Frequency (Interval)			6 (4-10)	14 (4-6)	0	0	0	1 (2)	3 (2-6)	2 (1)	0	7 (1-5)	2 (1-6)	19 (3-5)	1 (1)	1 (2)	12 (2-7)	7 (1-7)	0	10 (2-2)	0	0	0
Cumulative Weights (%)			5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	84	88	93	97	100
Maximum Level (da)			10	10	10	10	10	10	10	10	10	10	10	10	10	7	7	7	7	7	7	7	10
Minimum Level (da)			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Replication = 1,000; Maximum number of activities per plan = 6

The value of the variation might be considered from two aspects. The first is from a management preference point of view. Given the same resource supplies a particular farmer may prefer certain kinds of crops to others. This preference might be due to his familiarity or skill with the crop or to the low risk associated with the production of particular crops.

The second is the actual resource supply an individual farmer possesses, when the model used is designed for a group approach. The amount of land and water use, and of labour and capital are not always the same for each plan. A farmer can thus choose the plan with resource use most suitable for him.

6.2 A Multi-objective Considered

The total gross margin is not the only objective of farming, especially when a high total gross margin is associated with high risk and uncertainty. Carlsson et al. (1969) found in his analysis on a Swedish farm example, that 'In general, greater gross margin gives greater risk'. In his analysis, risk, as another objective besides the gross margin, is calculated as the standard deviation of the gross margin when variations in yield and price of products and factors are considered.

In this analysis, the total gross margin is considered as the first objective (Z_1), and the family labour use as the second (Z_2). Combining the two objectives together, the objective function of the farm is set out to be:

$$Z = Z_1^* - vZ_2$$

where $_1^*$ is the expected farm income, and v is the average valuation of family labour per man hour. In this analysis, $Z_1^* = \frac{2}{3} Z_1 - 25{,}000$ and $v = 35$ are used.

The value of $\bar{Z}$ can be referred to as a return to management by the residual method for calculating the returns to factors of production. Table 6.2 sets out the calculated values of $\bar{Z}$ for the twenty plans presented in the above section.

As shown in the last column of Table 6.2, most of the plans occupy a different rank with respect to $\bar{Z}$, although not entirely different. From this analysis it is shown that sub-optimal solutions in regard to total gross margins are also very important if other objectives as well as total gross margins are taken into consideration.

Figure 6.1 is another way of presenting the sub-optimal solutions to farmers or other decision makers. The twenty plans are shown diagramatically with respect to total gross margin ($\bar{Z}_1$) and expected income per man hour ($\bar{Z}_3 = \bar{Z}_1^*/22$). Different levels of $\bar{Z}_1$ and $\bar{Z}_3$ can be chosen as criteria for selecting the plans. For example, when only plans having total gross margins of at least 80 per cent of the linear programming optimal solution are of interest, it can be shown from the diagram that plans No.1 to No.10 can be chosen. But if another criterion is imposed, say that the income per man hour must be greater than Rp.37.50, only five plans, No.1, No.3, No.5, No.6 and No.8, fulfil the criteria. Preferences can still be given to these five plans according to their activity combination as presented in Table 6.1 of the above section.

TABLE 6.2

THE VALUES OF Z AND NEW RANKING OF THE TWENTY PLANS

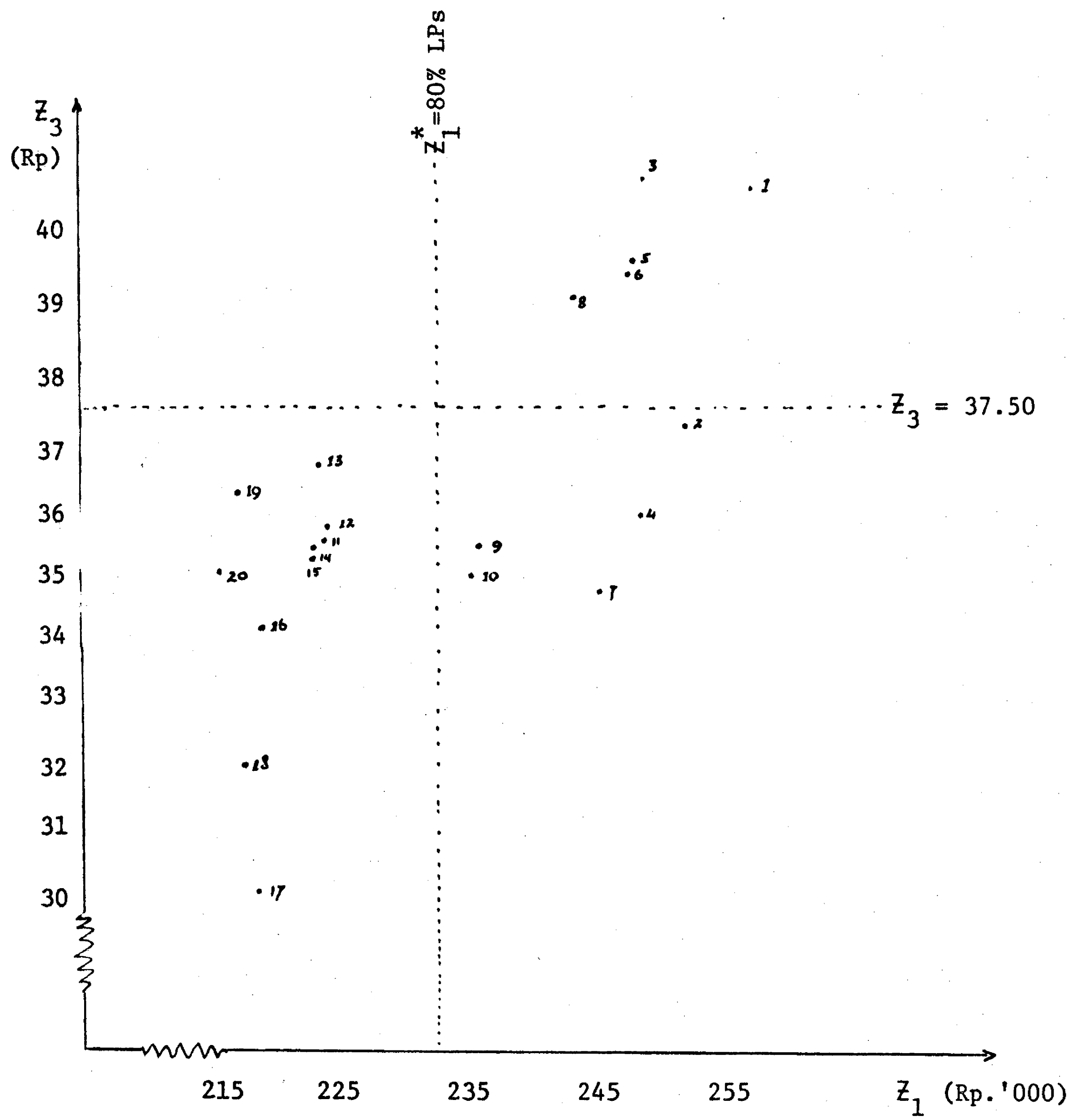
Plan No. 2nd Ranking	Z_1	Z_2	Z_1^*	Z	New Ranking
1	254,275	3,551	144,157	20,232	1
2	248,900	3,790	140,933	8,283	6
3	245,640	3,394	138,760	19,970	2
4	245,630	3,861	138,573	3,618	9
5	245,405	3,494	138,603	16,313	3
6	245,145	3,502	138,430	15,860	4
7	243,645	3,954	137,430	-960	17
8	240,970	3,471	135,647	14,162	5
9	234,330	3,703	131,220	1,614	12
10	233,065	3,724	131,122	782	15
11	223,325	3,465	123,883	2,608	10
12	223,330	3,486	123,820	1,810	11
13	222,970	3,370	123,647	5,697	7
14	222,935	3,494	123,623	1,333	13
15	222,320	3,484	123,213	1,273	14
16	218,720	3,551	120,813	-3,472	18
17	218,400	3,976	120,600	-18,560	20
18	217,095	3,717	119,730	-10,365	19
19	216,120	3,285	119,080	4,105	8
20	214,945	3,374	118,297	207	16

Notes: 1. $Z_1^* = \frac{2}{3} Z_1 - 25{,}000$, is the prospective farm income (25,000 is the common costs and $\frac{2}{3}$ is a coefficient to make allowance for less favourable yield and price).

2. $Z = Z_1^* - 35Z_2$, is the objective function (multi-objective), where 35 is assumed (an example) to be the average valuation of family labour per man hour.

FIGURE 6.1

THE DISTRIBUTION OF THE TOP TWENTY PLANS
WITH RESPECT TO Z_1 (TGM) AND Z_3 (INCOME PER MAN HOUR)



6.3 A Multistep Process of Simulation

The frequency and levels of activities included in the top twenty plans show their relative merit in building feasible and profitable plans. A second step of simulation can be performed by assigning different weights to each activity in proportion to its frequency of appearance in the twenty plans. The interval of its levels can then be used to specify the minimum and maximum level in the selection process. In this way, the efficiency of the selection procedure in the simulation is increased.

Since a wider range of plans is also considered important in this analysis, information from Phase I and from the linear programming solution as well as the more likely farmers' preferences are taken into consideration in assigning the weights and intervals of activities in the second step. This 'moderate' step results in a range of plans, the top one hundred of which are compared with the solutions of Phase I. Table 6.3 shows the frequency distribution of the plans falling in the same class intervals with respect to their total gross margin.

TABLE 6.3

THE DISTRIBUTION OF THE TOP HUNDRED PLANS IN THE FIRST AND SECOND STEP

No.	Class Interval of TGM (Rp)	Frequency Phase I	Phase II
1	2	3	4
1	183,400-202,200	52	0
2	202,300-223,800	32	0
3	223,900-245,500	9	68
4	245,600-252,700	6	20
5	252,800-260,000	1	10
6	260,100-262,900	0	2
LP	289,000		

It can be seen from Table 6.3 that plans in Phase II have a higher total gross margin compared with those of Phase I. Graphically, the frequency distribution has been shifted to the right. However, a very small proportion of the plans have total gross margins higher than 90 per cent of the optimal linear programming solution. This is understandable for smallholder farming with small scale operations and integer solutions (although the units are in 1/10 hectare). Downward adjustment of an activity of 6.86 da to 6.0 da (integer value), for example, means a reduction in the possible gross margin of more than 10 per cent.

6.4 Run with another Resource Supply

It is argued (section 6.1), that simulation analysis of this kind is also valuable in a group approach which considers the actual resource supplies of individual farmers. Since the resource supplies used for analysis in the foregoing sections are the average values, the range of solutions provided by the simulation excludes some solutions for those having resources or preferences above the average level. For example, it provides no solution for those who possess draught cattle themselves, nor for farmers who prefer growing 'gadu' in the dry season with an assured water supply. Such problems require further analysis.

CHAPTER 7

CONCLUDING REMARKS

The foregoing analysis suggests that linear programming and Monte Carlo simulation employed in a complementary fashion can provide useful guidance for better resource allocation in farm planning. In smallholder agriculture, these techniques are more readily justified for a group or regional approach, such as the farm planning for land settlement dealt with in the present analysis. It also clearly reveals the merit of a whole-farm planning approach, i. e., looking at the farm as a whole entity, in attempting to increase farm production and income.

This study serves mainly to show the usefulness of these two analytical techniques. The actual results must be treated with great caution owing to the limitations of the data used. However, to the extent that the data do reflect the real world situation of the study area, three important conclusions can be drawn.

1. Under the present situation of resource supplies and technology (Chapter 3 and Table 4.1), it is labour and capital which are particularly constraining, and not farmland, even with holdings smaller than the legal minimum size (2.0 hectares). Less than three-quarters of the available one hectare of sawah can be cultivated for rice in the wet season. The crops cultivated by the traditional methods and thus using less capital, are mostly the ones appearing in the optimal solution.

2. Some measures are available to improve the present resource productivity and farm income under the available irrigation. They are:

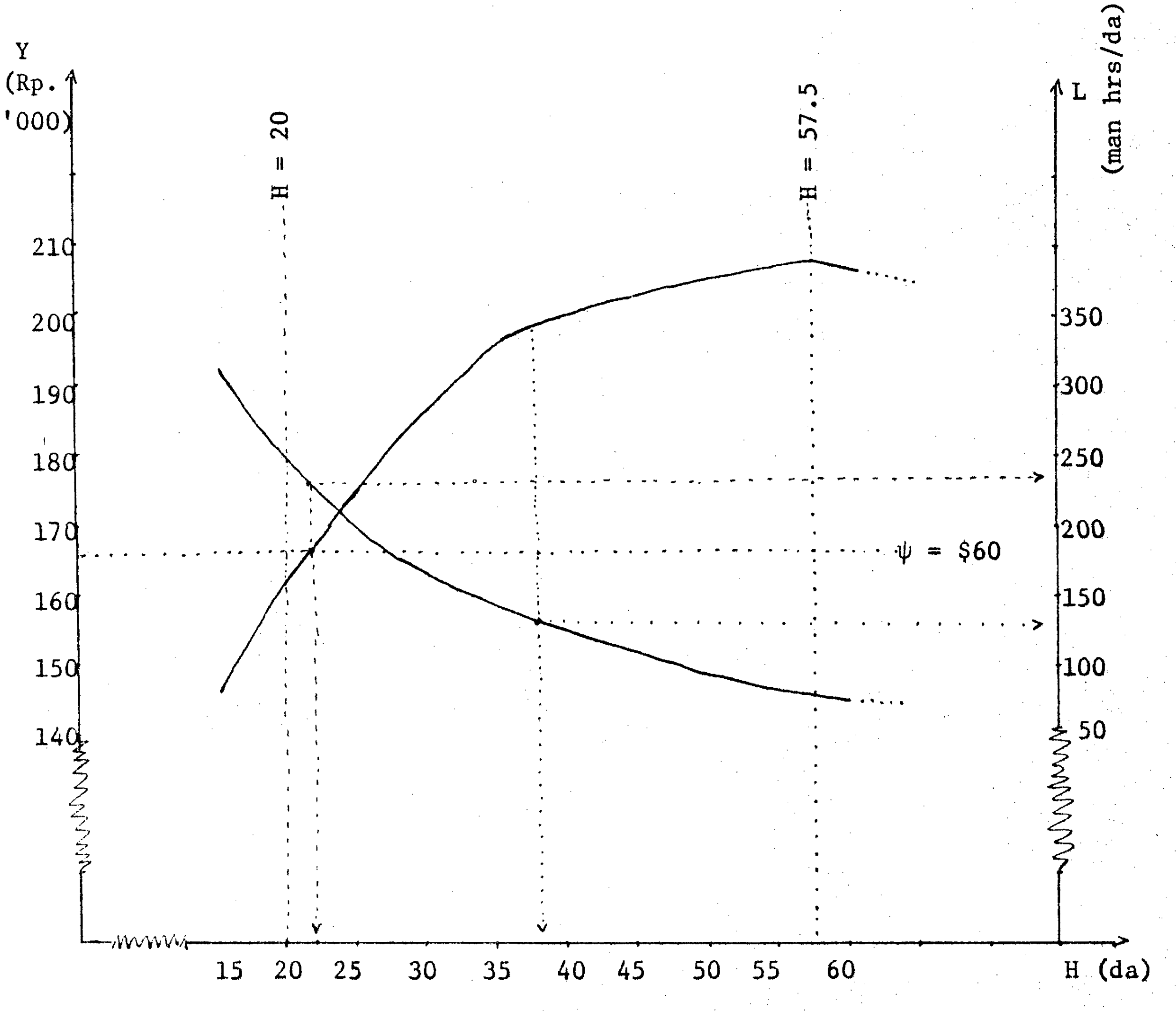
   i) Reallocation of the existing resource supply toward crop diversification. Growing diversified crops of 'palawiya' in the dry season sawah land will also resolve the problem of water shortage.

   ii) Introduction of improved cultural methods, and, at the same time, providing the necessary production credit and draught cattle. About Rp.17,000 - Rp.18,000 of cash supply is required and additional cattle at the rate of one pair for every three farms are necessary. More efficient methods of rice harvesting, such as the use of the sickle rather than the traditional 'ani-ani', are needed and additional harvesting labour of about 285 man - sickle - hours is necessary when improved rice is planted.

3. For future land settlement, the present analysis suggests that more non-sawah land should be allocated. Perennial cash crops can be planted on this land. No exact figure for the appropriate farm size is recommended; instead, a trade-off diagram showing the relationships between farm size, expected farm income, and employment absorption capacity of the settlement area, is presented (Figure 5.1).

FIGURE 7.1

THE TRADE-OFF DIAGRAM:
EXAMPLE OF IMPLICATIONS



For a typical farm analysed, i.e., a combination of sawah cultivation and coconut groves as appears in the optimal solution, the option of farm sizes in the range of 2.0 ha and 6.0 ha* may be considered, the former being the minimum size stipulated by law, and the latter being the maximum found to be cultivable in this analysis. The trade-off diagram is studied here in order to consider some possible implications.

In general, within the range 2.0 - 6.0 ha, the bigger the farm size the higher the income generated, but the smaller the employment absorption capacity of the settlement area. The range of the discussion can be made more specific if the objective of land settlement is more clearly defined.

For example, when a minimum income of US$60/cap./year is to be achieved - as say the opportunity cost of the migrant estate labourers in North Sumatra (IBRD, 1972) - at least 2.5 ha should be allocated. In an area of 1,000 ha net, 400 families can be settled. In this case, about 2,400 man hours will be employed for every hectare of land per hear with a corresponding income of Rp.42 per man hour of work (Table 5.10).

The maximum farm income is achieved at the maximum cultivable land of 6.0 ha, where only 167 families can be settled in 1,000 ha of land and less than 750 man hours can be absorbed on 1.0 ha per year. However, if the additional land is not given free, but has to be rented at Rp.5,000 per ha or an additional land tax of that amount is imposed,$^{\phi}$ it will only be profitable for the settlers to have a farm size of about 4.0 ha (Table 5.11).

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* Included here is the usual allocation for the homestead of 0.25 ha. The size shown in the diagram refers only to sawah and non-sawah farmland.

ϕ The present land tax for dry-land is only about Rp.1,000 per hectare, which might not cover even the costs of collection and administration.

The present study has some deficiencies and it is suggested that further thorough study in the following areas should be undertaken:

i) the collection of better quality data, especially on the input-output of each crop and livestock enterprise suitable for the study area and on the price structure;

ii) the use of a dynamic model, especially one which includes perennial crops, and the incorporation of inter-relationships between crops and livestock (mixed farming). Simulation will facilitate the treatment of this more appropriate model for land settlement.

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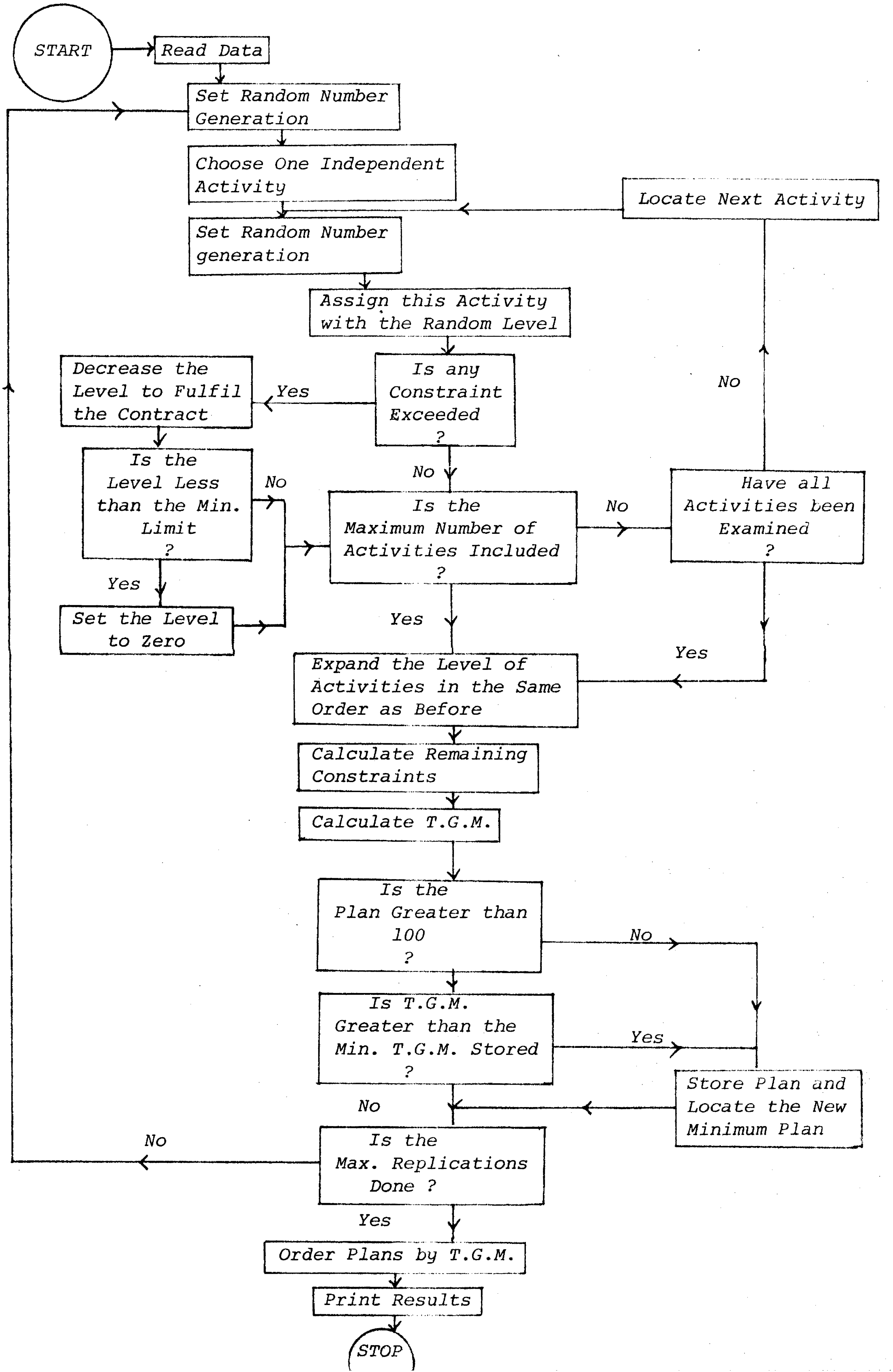
APPENDICES

APPENDIX A.1

FLOW CHART FOR MONTE CARLO SIMULATION



APPENDIX A.2

THE MONTE CARLO SIMULATION PROGRAM

```
      C
      C     M.A. WARDHANI --- APRIL 10, 1974 !
      C
      C     SIMULATION METHOD FOR FARM PLANNING ( MONTE CARLO )
      C     ADAPTED FROM DONALDSON AND WEBSTER WORK (1968)
      C     APPLIED TO WAY SEPUTIH LAND SETTLEMENT SCHEME
      C
            DIMENSION A(66,66),Z(170,100),MIN(66),MAX(66),E(66),C(66),
           *F(66),KX(100),KY(100),GM(66),W(170,100),IW(170,100)
      C
      C     READ DATA
      C
            READ (5,50) ITÑS
            READ (5,51) N1,N2
            READ (5,50) M1
            DO 1 J=1,N1
          1 A(I,J) =0.0
            DO 2 I=1,M1
          2 READ (5,52) (A(I,J),J=1,N1)
            READ (5,52) (GM(J),J=1,N1)
            READ (5,53) (C(I),I=1,M1)
            READ (5,54) (E(J),J=1,N1)
            READ (5,55) (MIN(J),J=1,N1)
            READ (5,55) (MAX(J),J=1,N1)
            READ (5,50) MAXNO
            READ (5,50) IY
         50 FORMAT (I5)
         51 FORMAT (2I5)
         52 FORMAT (11F7.2)
         53 FORMAT (11F7.2)
         54 FORMAT (25F3.0)
         55 FORMAT (25I3)
      C
      C     INITIALIZE RANDOM NUMBER GENERATION
      C
            YFL=RAND(IY)
            M=1+M1+N2
      C
      C     SET ITERATION CYCLE
      C
```

(Appendix A.2 - continued)

```
      DO 7 IT=1,ITNS
      DO 38 J=1,N2
   38 MAX(J)=MAX(J)+1
      K = 0
      DO 8 J=1,N2
    8 KX(J) = 0
      DO 17 I=1,M1
   17 F(I)=C(I)
C
C     SELECTION OF ACTIVITY
C
    9 YFL=RAND(0)
      YFL=100.0*YFL
      J=1
   10 IF (E(J).GE.YFL) GO TO 11
      J = J+1
      GO TO 10
   11 IF (KX(J).NE.0) GO TO 9
C
C     SEEKING THE ACCEPTABLE LEVEL OF ACTIVITY
C
      YFL=RAND(0.0)
      DIFF = MAX(J)-MIN(J)
      LEVEL= YFL*DIFF
      XLEV= LEVEL+MIN(J)
      K= K+1
      KY(K)= J
      LEVEL= XLEV
      DO 13 I= 1,M1
*DIAGNOSTIC*  THE TEST FOR EQUALITY BETWEEN NON-INTEGERS MAY NOT BE MEANINGFUL.
      IF (A(I,J).EQ.0.0) GO TO 13
      IF (F(I).GE.(XLEV*A(I,J))) GO TO 13
      XLEV=F(I)/A(I,J)+0.000001
      LEVEL = XLEV
      IF(MIN(J).GT.LEVEL) GO TO 14
   13 CONTINUE
      XLEV= LEVEL
      IF (LEVEL.EQ.0) GO TO 14
      DO 15 I=1,M1
      F(I)= F(I)-(XLEV*A(I,J))
   15 CONTINUE
      KX(J)= LEVEL
      GO TO 16
   14 KX(J)= -1
```

(Appendix A.2 - continued)

```
 16    IF (K.LT.MAXNO) GO TO 9
C
C   FINALIZE LEVEL
C
       DO 39 J= 1,N2
 39    MAX(J)= MAX(J)-1
       DO 23 K= 1,MAXNO
       J= KY(K)
       IF (KX(J).LE.0) GO TO 23
       KXINIT= KX(J)
C
C   EXPAND ACTIVITIES TO LIMIT OF SMALLEST REMAINING RESOURCE
C
       KXMIN= 100000
       DO 19 I=1,M1
       IF (A(I,J).LE.0.0) GO TO 19
       KB=F(I)/A(I,J)+0.000001
       IF (KB.LE.1) GO TO 20
       IF (KB.GT.KXMIN) GO TO 19
       KXMIN= KB
 19    CONTINUE
       GO TO 21
 20    KXMIN=0
 21    KX(J)= KX(J)+KXMIN
       IF (MAX(J).GE.KX(J)) GO TO 22
       KXMIN= MAX(J)-KXINIT
       KX(J)= MAX(J)                 C
 22    XMIN= KXMIN                   C   Recalculate the remaining constraints
       DO 37 I=1,M1                  C
 37    F(I)= F(I)-(XMIN*A(I,J))
 23    CONTINUE
C
C   COMPUTE TOTAL GROSS MARGIN
C
       GMRA= 0.0
       DO 25 K= 1,MAXNO
       J= KY(K)
       IF (KX(J).LE.0) GO TO 25
       X = KX(J)
       GMRA= GMRA+(X*GM(J))
 25    CONTINUE
       TGM= GMRA
C
C   SELECT HUNDRED TOP PLANS
C
       IF (IT.GT.100) GO TO 30
       L= IT
```

(Appendix A.2 - continued)

```
              GO TO 31
   30         IF (TGM.LT.TGMIN) GO TO 7
              L= LMIN
C
C     STORE TOTAL GROSS MARGIN
C
   31         Z(1,L)= TGM
              DO 32 I= 2,M
   32         Z(I,L)= 0.0
C
C     STORE ACTIVITIES AND LEVELS
C
              I= 2
              DO 33 J= 1,N2
              IF (0.GE.KX(J)) GO TO 33
              Z(I,L)= KX(J)
   33         I= I+1
C
C     STORE REMAINING CONSTRAINTS
C
   94         DO 35 J= 1,M1
              Z(I,L)= F(J)                    C
   35         I= I+1                          C   Locate new minimum plan
              IF (IT.LT.100) GO TO 7          C
              TGMIN= Z(1,1)
              LMIN= 1
              DO 36 K=1,100
              IF (TGMIN.LT.Z(1,K)) GO TO 36
              TGMIN= Z(1,K)
              LMIN= K
   36         CONTINUE
    7         CONTINUE
C
C     ORDER PLANS BY TOTAL GROSS MARGIN
C
              DO 88 I=1,100
              ZMAX= Z(1,1)
              LMAX= 1
              DO 86 K=1,100
              IF ( ZMAX.GE.Z(1,K)) GO TO 86
              ZMAX= Z(1,K)
              LMAX= K
   86         CONTINUE
              DO 87 J= 1,M
              W(J,I)= Z(J,LMAX)
   87         Z(J,LMAX)= 0.0
   88         CONTINUE
```

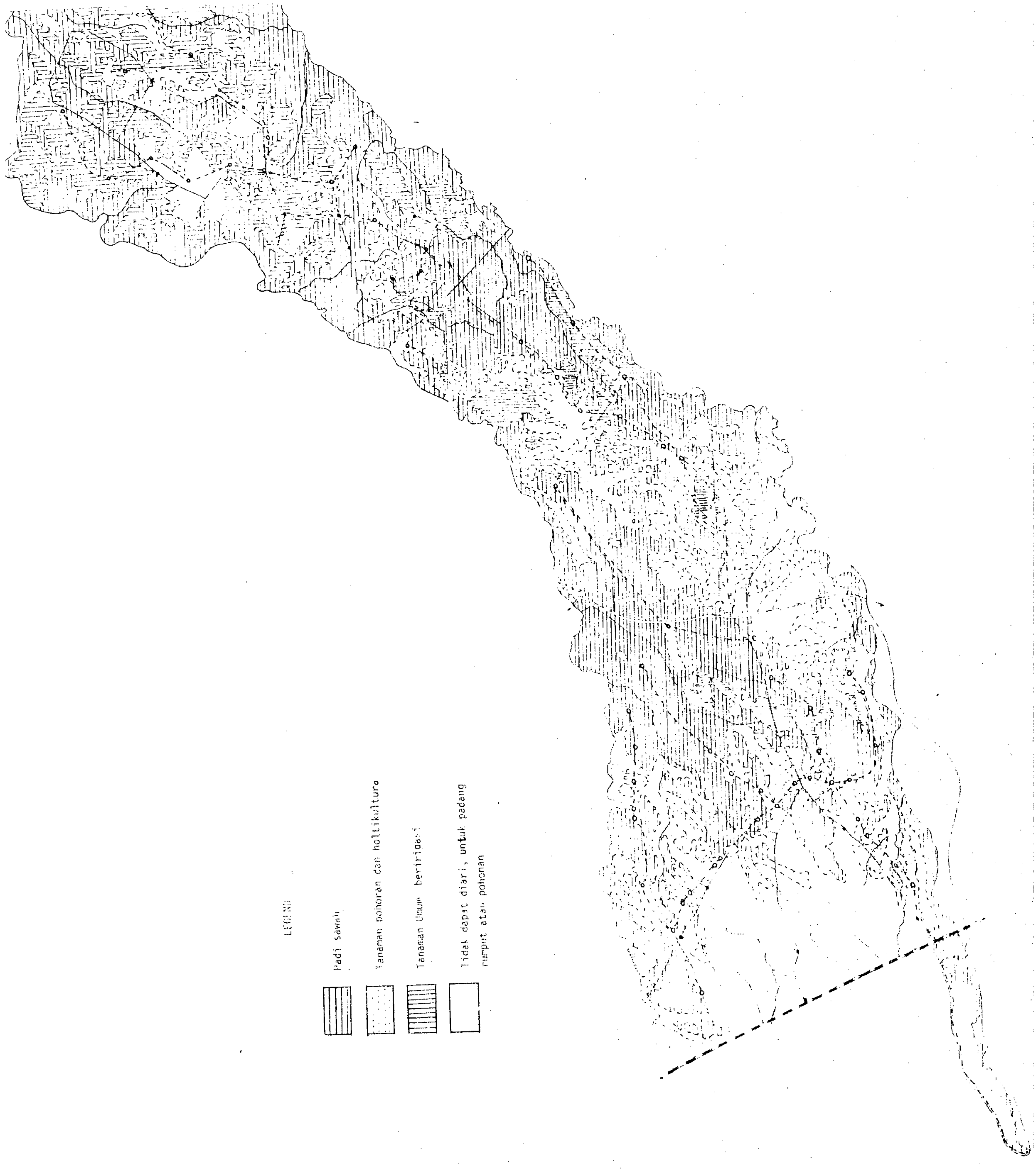
(Appendix A.2 - continued)

```
      C
      C    PRINT RESULTS
      C
            WRITE (6,300)
      300   FORMAT (1H1,43X,35HTOP HUNDRED PLANNING OUTPUT TABLEAU )
            DO 500 NO=1,10
            L=10*NO-9
            K=10*NO
            DO 40 J=L,K
      40    KY(J)= J
            WRITE (6,310) (KY(J),J=L,K)
      310   FORMAT (4X ,'PLAN NO',10(7X,I2,3X))
            WRITE (6,320) (W(1,J),J=L,K)
      320   FORMAT (4X ,'T.G.M.',10F12.2)
            WRITE (6,330)
      330   FORMAT (4X ,10HACTIVITIES)
            I=2
            DO 45 N= 1,N2
            DO 89 J= L,K
            IW(I,J) = W(I,J)
      89    CONTINUE
            WRITE (6,340)N,(IW(I,J),J=L,K)
      340   FORMAT (4X ,I2,10X,9(I4,8X),I4)
      45    I= I+1
            WRITE (6,350)
      350   FORMAT (4X ,'THE REMAINING CONSTRAINTS')
            DO 47 N=1,M1
            WRITE (6,360) N,(W(I,J),J=L,K)
      360   FORMAT (4X ,I2,5X,10(4X,F8.2))
      47    I=I+1
            WRITE (6,370)
      370   FORMAT (1H1)
      500   CONTINUE
            END

END OF COMPILATION:          1 DIAGNOSTICS.
```

APPENDIX B.1

THE DISTRIBUTION OF LAND CLASSES
AND THE LAND USE RECOMMENDATIONS



APPENDIX B.2

CLIMATOLOGICAL DATA BASED ON OBSERVATIONS MADE AT BRANTI AIRPORT

MONTH	TEMPERATURE (°C)			Relative Humidity %	Radiation Duration %	WIND	
	Max.	Mean	Min.	Mean		Direction	Velocity
January	30.8	27.1	23.2	72	36	N.W.	5.8
February	30.5	26.9	23.4	74	30	N.W.	5.8
March	31.1	27.2	23.4	73	32	N.W.	4.8
April	31.2	27.6	23.5	72	41	S.E.	4.6
May	31.9	28.0	23.7	72	39	S.E.	5.0
June	31.8	27.3	24.2	70	35	S.E.	6.2
July	31.7	26.8	22.8	71	59	S.E.	5.2
August	32.2	27.0	22.2	66	61	S.E.	5.4
September	32.3	27.7	22.2	64	69	S.E.	5.6
October	32.4	28.5	22.8	65	41	S.E.	4.4
November	31.7	28.1	23.8	67	33	S.E.	4.4
December	31.7	27.8	24.2	72	25	N.W.	5.0
Average	31.6	27.5	23.3	69.8	41.8	-	5.18

Source: Faculty of Agriculture, Bogor Agricultural University. "Way Pengubuan Irrigation Project, Agricultural Survey Report", Bogor, October, 1969, p.31.

APPENDIX B.3(a)

LAND USE IN LAMPUNG, 1972

No.	Usage	sq. km	%
1	Sawah	57.100	1.73
2	Oil Palm	2.300	0.07
3	Rubber	24.900	0.75
4	Coffee	39.800	1.21
5	Pepper	28.700	0.87
6	Alang-Alang Grass	170.800	5.20
7	Mixed Groves	431.208	13.13
8	Hamlets	38.500	1.17
9	Swamps	42.700	1.30
10	Forest	2,446.100	74.57
	TOTAL	3,282.100	100.00

APPENDIX B.3(b)

QUANTITATIVE CHANGES OF LAND USE CLASSES OVER A PERIOD OF 15 YEARS
(1954-1969)

I. OFFICIAL TRANSMIGRATION

(Eastern Part of Way Seputih)

LAND USE CLASSES	AREA (%)		AREA (ha)	
	1954	1969	1954	1969
A. Natural Vegetation	98.0	10.1	2.695	227
1. Not degraded (jungle)	8.1	-	223	-
2. Degraded (F+B)	60.7	0.4	1.668	11
3. Strongly degraded (A)	29.2	9.7	804	866
B. Cultivated and Planted Land	2.0	89.9	55	2.475
1. Very non-intensive (U_1)	-	13.2	-	365
2. Non-intensive (U_2)	1.1	10.3	31	280
3. Fairly intensive (U_3)	-	44.3	-	1.220
4. Intensive (I+R+P+H)	0.9	22.1	24	608
	100.0	100.0	2.750	2.750

II. SPONTANEOUS TRANSMIGRATION

(Kecamatan Bougun regio., Central Lampung)

A. Natural Vegatation	97.1	54.1	3.592	1.999
1. Not degraded (jungle)	56.7	-	2.098	-
2. Degraded (F+B)	33.0	2.3	1.221	84
3. Strongly degraded (A)	7.4	51.8	273	1.915
B. Cultivated and Planted Land	2.9	45.9	108	1.701
1. Very non-intensive (U_1)	2.0	7.9	78	293
2. Non-intensive (U_2)	-	0.6	-	24
3. Intensive (I+R+P)	0.9	37.4	30	1.374
	100.0	100.0	3.70	3.700

(Appendix B.3(b) - continued)

CODE:

1)	J	=	Jungle
2)	F	=	Secondary forest
3)	B	=	Bush and shrub
4)	A	=	Alang-alang
5)	U_1	=	Very non-intensive upland crops (numerous alang-alang) maize, cassava, rainfed paddy.
6)	U_2	=	Non-intensive upland crops (numerous alang-alang)
7)	U_3	=	Fairly intensive upland crops (some alang-alang)
8)	R	=	Rubber plantation
9)	P	=	Irrigated paddy
10)	H	=	Homestead garden associated with scattered houses, vegetables, ground nut, cassava.
11)	I	=	Intensive orchards associated with numerous houses, coconut, fruit trees.

Data taken from Schwaar, D.C.: "Land Use and Transmigration in Southern Sumatra" (1972), as cited in Bonn (1973), pp.50-51.

APPENDIX B.4

EXPORTS OF SOME AGRICULTURAL PRODUCTS IN LAMPUNG (1967-1972)

COMMODITY	VOLUME (tons)				
	1967	1968	1969	1970	1971
Maize	26.651	29.047	38.546	46.221	68.221
Gaplek	2.670	15.000	45.300	73.541	86.287
Gaplek	3.666	1.250	1.450	100	-
Tapioka flour	1.060	1.037	2.893	328	2.857
Tapioka 'ampas'	-	-	26	323	305
Dedak (bran)	1.000	1.036	1.905	3.312	1.853
Soybean	-	2.702	-	25	-
Dried Red Spanish Pepper	-	-	-	-	5
Estate rubber	5.101	4.748	4.419	5.347	4.780
Smallholder rubber	39.364	45.845	49.483	34.064	14.623
Crumb rubber (SIR)	-	-	-	2.654	10.205
Coffee	42.662	24.935	40.579	26.985	14.623
Black pepper	29.295	20.756	10.910	1.263	17.639
Copra 'bungkil'	4.330	4.250	3.600	5.823	6.032
Palm	150	100	125	-	-
Palm kernel	-	-	25	-	-
Timber	4.512	5.904	24.716	81.649	224.510

SOURCE: Lampung Laporan Tahunan 1971.
Dinas Pertanian Rakjat Propinsi Lampung, p.60.

APPENDIX B.5

THE AVERAGE POSSESSED AND CULTIVATED LAND, 1970
(in ha)

FARM GROUP	No. of Samples	Sawah (1)		Swampy land (2)		Upland (3)		Plantation (4)		Homestead (5)		Total		TOTAL (1)-(4)	
		P	C	P	C	P	C	P	C	P	C	P	C	P	C
I. Sawah Farmer															
1. Javanese settlers	14	.83	.55	.04	.02	1.53	.30	-	-	.18	.17	2.58	1.04	2.40	.87
2. Army settlers	8	.69	.67	-	-	1.00	.14	-	-	.33	.29	2.02	1.11	1.69	.81
AVERAGE OF I.	22	.78	.60	.02	.01	1.34	.24	-	-	.23	.21	2.37	1.06	2.14	.85
II. Dryland Farmer															
1. Javanese settlers	18	.08	-	.13	.04	1.07	.82	-	-	.28	.22	1.56	1.08	1.28	.86
2. Balinese settlers	10	-	-	-	.05	2.45	.85	-	-	.25	.25	2.70	1.15	2.45	.90
3. Indigenous	9	-	-	.03	-	4.97	.53	.82	.63	.24	.24	6.06	1.40	5.82	.53
AVERAGE OF II.	37	.04	-	.07	.03	2.38	.76	.20	.15	.26	.24	2.95	1.18	2.49	.79

SOURCE: IPB, Survey Social Ekonomi, 1971, Tables F.3 and F.4

APPENDIX B.6

THE RESULTS OF SOME FERTILIZER EXPERIMENTS

I. The Results of a Fertilizer Experiment with Corn in Barodati, 1968/1969:

Treatment N	- P	- K	Average Yield (kg/ha)
0	0	0	1,816
30	0	0	2,344
30	30	0	2,464
30	30	30	2,505
60	0	0	2,806
60	30	0	3,319
60	30	30	3,363
60	60	30	3,401
120	0	0	3,965
120	30	30	4,808
120	60	30	5,060

SOURCE: IPB: Way Pengubuan, 1969, p.223.

(Appendix B.6 - continued)

II. The Results of a Fertilizer Experiment with rice (PB.5) in Two Podsolic Soils of Central Lampung, 1971:

TREATMENT N - P	AVERAGE YIELDS (kg/ha)	
	Raman Utara	W. Sekampung
0 - 30	3,500	3,567
45 - 0	3,794	3,400
45 - 60	4,888	4,027
90 - 30	4,901	4,305
135 - 0	3,277	3,978
135 - 60	4,388	4,926
180 - 30	4,185	4,738

SOURCE: Lampung, Dihas Pertanian Rakjat Propinsi Lampung, Laporan Tahunan 1971. pp.181-183.

APPENDIX C

THE INPUT/OUTPUT MATRIX OF THE BASE SITUATION

ACTIVITIES / RESOURCES	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}	Type Vector	Constraint (b)
GM	5,910	12,000	5,620	12,050	1,875	6,965	3,625	5,170	8,530	5,600	10,700	24,900	17,015	7,175	8,635	4,070	8,130	4,200	5,100	6,000	10,150	.20	-30	-20	-30		
1 WIRSL	1	1																								≤	10
2 DIRSL			1	1	1	1	1	1	1	1	1	1	1													≤	10
3 DIRWAT			1	1	.15	.20	.12	.15	.15	.12	.20	.15	.20													≤	2.5
4 SANOL														1	1	1	1	1	1	1						≤	7
5 PEAKW1	91.2	126.4															46.0		9.8		98.0	-1				≤	840
6 ORDW1	10.5	24.5												125.3	111.3	133.0	94.5	130.2	28.2	7.7	238.0					≤	1,139
7 PEAKW2	27.5	52.5												21.0					3.6		28.0		-1			≤	240
8 PEAKD1			80.6	98.4	66.5	92.4	19.6	87.5	88.2		91.0	129.5	78.2	7.0					9.0		52.5			-1		≤	600
9 ORDD1			9.0	24.5	9.1	18.9	7.7	14.7	15.4	123.9	10.5	91.5	51.3	17.5	45.5		33.5		25.2	6.3	147.0					≤	1,005
10 PEAKD2			1.5	52.5	5.6	14.0	17.5	24.5	28.0		28.0	10.0	13.1				30.0		5.6		42.0				-1	≤	360
11 ORDD2			27.5														50.0		4.2	4.9	31.5					≤	201
12 HIPW1																						1				≤	75
13 HIPW2																							1			≤	120
14 HIPD1																								1		≤	50
15 HIPD2																									1	≤	180
16 CASWET	180	1,000												925	1,325	1,430	240	1,400	400	500	3,000	20				≤	5,000
17 CADRY			180	1,000	125	1,035	225	1,430	1,670	1,400	300	2,350	1,735	900					500	700	3,000			20	20	≤	5,000

APPENDIX D.1

FARM INCOME IN THE OPTIMAL PLANS

The farm income here is calculated from the optimal LP solution, which gives the Total Gross Margin (TGM) and the amount of labour use. The income is the TGM minus the Common Costs.

COMMON COSTS:

1. Land tax and water charge (assumed to be charged)

- sawah land	=	10 x Rp.250	=	Rp. 2,500
- non-sawah land	=	7 x Rp.100	=	Rp. 700
- dry season water	=	1.7 x Rp.150	=	Rp. 258
		Add (1)=		Rp. 3,458

2. Interest on capital (3.5% a month)

- wet season	=	6 x 0.035 x Rp.5,000	=	Rp. 900
- dry season	=	6 x 0.035 x Rp.5,000	=	Rp. 900
		Add (2)=		Rp. 1,800

3. Depreciation on equipment and other capital assets for farm operations is estimated (roughly) .. .. Rp. 9,000

4. Unspecified .. .. Rp. 742

TOTAL Rp.15,000

(Appendix D.1 - continued)

EXPECTED INCOME:

To arrive at the likely expected incomes, allowance is given to less favourable yields and prices. The optimal solution gives TGM of Rp.189,000 and family labour use of 3,377 man hours.
Common Cost (above) = Rp.15,000.

Allowance	TGM (Rp)	Income (Rp)	Income/man hours (Rp/man hour)
0	189,000	174,000	51.5
$^1/_5$	151,200	136,200	40.3
$^1/_4$	141,750	125,750	37.2
$^1/_3$	126,000	111,000	32.9
$^1/_2$	94,500	79,500	23.5

Compared with prevailing wage rate in public works sector of about Rp.225 a day or Rp.32.14 an hour (not readily available anyhow), the assumed allowance of $^1/_3$ will be used for further analysis.

NOTE: For the future farming with improved resource supply, the common costs will be assumed to be Rp.25,000.

APPENDIX D.2

THE PRESENT INCOME

FARM INCOME:

For the sawah farmers, the average land cultivated is 0.61 ha of sawah plus 0.24 ha of dry-land. The sawah is assumed to be doubled-crop with rice, and the mixed crops rice-maize-cassava grown in the dry-land. The income is calculated on the basis of the gross return (1972-1973 prices) and the information on the output/input ratios of the cropping system.

Gross Return (favourable assumption)

		Area (ha)		Yield (kg/ha)		Price (Rp/kg)		Gross Return (Rp)
Sawah:	rice	.61	x	1,800	x	29	=	31,842
	rice	.61	x	1,800	x	29	=	31,842
				Sub-total			=	Rp.63,684
Dry-land:	rice	.24	x	900	x	29	=	6,264
	maize	.24	x	350	x	20	=	1,680
	cassava	.24	x	5,000	x	4	=	4,800
				Sub-total			=	Rp.12,744

Income (favourable assumption)

	Gross return (Rp)	O/I ratio	Income (Rp)
Sawah:	63,684	4:1	47,763
Dry-land:	12,744	5:1	10,195
			Rp.57,958

To give allowances for less favourable yield and price, a factor of $^1/_3$ (as applied in the optimal plan, too) is used. Thus the present farm income =

$$^2/_3 \times \text{Rp.}57{,}958 = \text{Rp.}38{,}639$$

(Appendix D.2 - continued)

OFF-FARM INCOME:

The Javanese settlers are taken in preference to the Army settlers because the latter receive a pension in excess of other incomes (more than Rp.60,000 a year). The off-farm income, in terms of 1970 prices, is Rp.28,309 while farm income is Rp.26,039. The off-farm income calculated in 1972-73 prices and wages is:

$$28{,}309 \times \frac{38{,}639}{26{,}039} = \text{Rp.}41{,}897$$

Thus this income has been estimated by increasing it at the same proportionate rate as the known increase in farm incomes.

TOTAL FAMILY INCOME:

$$\text{Rp. } 38{,}639 + \text{Rp.}41{,}897 = \text{Rp.}80{,}536$$

$$\text{per capita} = \frac{\text{Rp.}80{,}536}{6.6} = \text{Rp.}12{,}202 = \underline{\underline{\text{US\$29.40}}}$$

INCOME PER MAN HOURS:

	Total (Rp)	Work (man hours)	Per man hr. (Rp)
Farm Income	38,639	174 x 7	31.7
Off-farm Income	41,897	120 x 7	49.9
Total Income	80,536	294 x 7	39.1

APPENDIX E

AN EXAMPLE OF SIMULATION SOLUTIONS

(Top Hundred Planning Output Tableau)

PLAN ID	1	2	3	4	5
T.G.M.	262845.00	262845.00	259575.00	259575.00	257245.00
ACTIVITIES					
1	0	0	0	0	0
2	6	6	6	6	6
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	1	1	2	2	0
11	0	0	0	0	0
12	5	5	5	5	5
13	0	0	0	0	0
14	0	0	0	0	0
15	7	7	5	5	7
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	2	2	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
THE REMAINING CONSTRAINTS					
1	4.00	4.00	4.00	4.00	4.00
2	4.00	4.00	3.00	3.00	5.00
3	.00	.00	.00	.00	.00
4	156.60	156.60	156.60	156.60	156.60
5	212.90	212.90	175.10	175.10	212.90
6	45.00	45.00	45.00	45.00	45.00
7	2.50	2.50	2.50	2.50	2.50
8	105.10	105.10	72.20	72.20	229.00
9	490.00	490.00	490.00	490.00	490.00
10	2.01	2.01	2.01	2.01	2.01
11	4725.00	4725.00	4575.00	4575.00	4725.00
12	6850.00	6850.00	5450.00	5450.00	8250.00
13	1.63	1.63	1.51	1.51	1.75

(Appendix E - continued)

6	7	8	9	10
257245.00	256785.00	256765.00	256175.00	255785.00
0	4	4	0	0
6	4	4	6	6
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	3	3
0	0	0	0	0
5	5	5	5	5
0	0	0	0	0
0	0	0	0	0
7	7	7	3	3
0	0	0	1	4
0	0	0	0	0
0	0	0	3	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
4.00	2.00	2.00	4.00	4.00
5.00	5.00	5.00	2.00	2.00
.00	.00	.00	.00	.00
156.60	44.60	44.60	156.60	156.60
212.90	219.90	219.90	134.50	126.10
45.00	40.00	40.00	45.00	45.00
2.50	2.50	2.50	2.50	2.50
229.00	229.00	229.00	39.30	39.30
490.00	490.00	490.00	490.00	490.00
2.01	2.01	2.01	2.01	2.01
4725.00	6005.00	6005.00	4395.00	4305.00
8250.00	8250.00	8250.00	4050.00	4050.00
1.75	1.75	1.75	1.39	1.39

(Appendix E - continued)

PLAN NO	11	12	13	14	15
T.G.N.	255785.00	252695.00	252660.00	251030.00	250690.00
ACTIVITIES					
1	0	0	0	0	0
2	6	6	6	6	6
3	0	0	0	0	0
4	0	0	0	1	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	2	0	0	3
8	0	0	0	0	0
9	0	0	0	0	0
10	3	3	0	2	3
11	0	2	0	0	0
12	0	3	5	4	4
13	0	0	0	0	0
14	0	0	0	0	0
15	3	7	6	6	5
16	4	0	1	1	2
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
THE REMAINING CONSTRAINTS					
1	4.00	4.00	4.00	4.00	4.00
2	2.00	.00	5.00	3.00	.00
3	.00	.00	.00	.00	.00
4	156.60	156.60	156.60	156.60	156.60
5	126.10	212.90	191.20	191.20	169.50
6	45.00	45.00	45.00	45.00	45.00
7	2.50	40.30	2.50	33.60	73.20
8	39.30	3.90	274.50	93.70	16.70
9	490.00	419.00	490.00	447.50	447.50
10	2.01	2.51	2.01	2.01	2.01
11	4305.00	4725.00	4620.00	4620.00	4515.00
12	4050.00	7700.00	8250.00	6800.00	5725.00
13	1.39	1.05	1.75	.66	1.18

(Appendix E - continued)

16	17	18	19	20
250185.00	249995.00	249540.00	248600.00	248600.00
0	0	0	0	0
6	6	6	6	6
0	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
2	1	1	4	4
0	0	0	0	0
5	4	5	5	5
0	0	0	0	0
0	0	0	0	0
3	7	4	0	0
4	0	0	0	0
0	0	0	0	0
0	0	3	7	7
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
4.00	4.00	4.00	4.00	4.00
3.00	4.00	4.00	1.00	1.00
.00	.00	.00	.00	.00
156.60	156.60	156.60	156.60	156.60
126.10	212.90	156.20	80.60	80.60
45.00	45.00	45.00	45.00	45.00
2.50	33.60	2.50	2.50	2.50
163.20	172.10	241.60	51.90	51.90
490.00	447.50	490.00	490.00	490.00
2.01	2.01	2.01	2.01	2.01
4305.00	4725.00	4500.00	4200.00	4200.00
5450.00	8200.00	6850.00	2650.00	2650.00
1.51	.78	1.63	1.27	1.27

PARTS REQUIRED IN FIELD WORK	PART NUMBER
1. Heater control circuit board	88-4343
2. Reciprocation circuit board	88-4247
3. Jam detection circuit board	88-4339
4. Rectifier circuit board	88-4270
5. Shear pins	X33-330162
6. Fan bearings	X71-0205
7. Skirt blades	87-263604
8. Wiper blades	87-1327-04
9. Tank wiper blade	89-4453-03
10. AC Corona assembly	
11. Positive corona assembly	
12. Paper separating sub assembly	
13. NP70 pickup rollers	87-2837-03
14. Blade drum Squirrel cage type	89-4453-03
15. Motor blade drum drive	X61-2164-02
16. ATR sub assembly	
17. Sprocket main drive	87-3049-06
18. Spring tension	97-5623-01
19. Ring Etype retaining	X32-401641
20. Copy board cable	89-4700
21. Exposure lamps	X61-7134
22. Overall exposure lamps	X62-7590
23. Main drive motor	X61-2166-01
24. Thermo fuses	X62-0803-03
25. Separation belt pads	87-2924
26. Corona wire	Y81-0162-000
27. Copy selector assembly	
28. Pilot lights on control panel assembly	Yellow, red,orange
29. Heater assembly late series	
30. Roller separation (rubber)	87-2936-02
31. Idler sprocket (nylon)	87-2951-02
32. Idler sprocket (nylon)	87-3050-04