OPTIMIZATION OF ENTERPRISE COMBINATIONS WITH SPECIAL REFERENCE TO GARDEN LAND AGRICULTURE

BY

JAYACHANDRAN. N. V.

THESIS

Submitted in partial fulfilment of the

requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Agricultural Economics

COLLEGE OF HORTICULTURE

Vellanikkara - Trichur

1985

DECLARATION

I, hereby declare that this thesis entitled "Optimization of Enterprise Combinations with special reference to Garden land Agriculture" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
August 28, 1985.

(JAYACHANDRAN M.V.)

CERTIFICATE

Certified that this thesis entitled "Optimization of Enterprise Combinations with special reference to Garden land Agriculture" is a record of research work done independently by Mr. Jayachandran, ..V., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

T. Prabhakaran

Vellanikkara
August , 1985.

(Dr. T. PRABHAKARAN)
Chairman,
Advisory Board,
Professor of Animal Production
Economics.

CERTIFICATE

We, the undersigned members of the Advisory Board of Mr. Jayachandran, N.V., a candidate for the degree of Master of Science in Agriculture with major in Agricultural Economics, agree that the thesis entitled "Optimization of Enterprise Combinations with special reference to Garden land Agriculture" may be submitted by Mr. Jayachandran, N.V., in partial fulfilment of the requirement for the degree.

Dr. T. PRABHAKARAN,
Chairman,
Advisory Board.

Dr. V. RADHAKRISHNAN,
Member.

Mr. V.K.G. UNNITHAN,
Member.

Dr. K. MUKUNDAN
Member.

ACKNOWLEDGEMENTS

I acknowledge, with much gratitude, my complete indebtedness to Dr. T. Prabhakaran, Professor of Animal Production Economics and Chairman of the Advisory Committee, in the successful preparation of this thesis work.

To Mr. V.K.G. Unnithan, Associate Professor of Agricultural Statistics, Mr. P.V. Prabhakaran, Professor of Agricultural Statistics, and Dr. M.V. George, Advisor, Agricultural Economics, Kerala Agricultural University, I am considerably thankful for providing insights into the mathematical and practical aspects of optimization problems.

I am grateful to Dr. V. Radhakrishnan, Professor and Head, Department of Agricultural Economics, and Dr. K. Mukundan, Associate Professor of Agricultural Economics, for reviewing the manuscript and suggesting useful revisions.

I thank the Indian Council of Agricultural Research for the junior research fellowship, which helped me financially, through my post graduate studies and research.

Vellanikkara,
August 22, 1985

(JAYACHANDRAN N.V.)

CONTENTS

LIST OF TABLES

ILLUSTRATION

Fig. 1. Net margins of activities under I, II, III and IV categories of holdings.

LIST OF APPENDICES

VI. (i) Flow of costs and returns and present worth of costs and returns for pepper - category I.

(ii) Flow of costs and returns and present worth of costs and returns for pepper - category II.

(iii) Flow of costs and returns and present worth of costs and returns for pepper - category III and IV.

Introduction

INTRODUCTION

The cropping pattern in Kerala state, in comparison with the general pattern of cropping for the country as a whole, exhibits sharp differences. While some of the major all India crops like wheat, barley, bajra and maize are not grown in the state, farmers of Kerala cultivate a variety of crops rarely found in other parts of the country. This distinction can clearly be brought out by refering to the statistics on the area under principal crops in India, and the area under the same crops in Kerala. In the year 1982-'83, 93 per cent of the gross cropped area in the country was collectively under cereals, millets, pulses, groundnut, oil seeds, sugarcane, cotton and jute, the corresponding figure for the state being only 30 per cent. The contrast becomes clearer, if rice, which occupied 22 per cent of the gross cropped area of the country and 27 per cent of the gross cropped area of the state during 1982-'83, is excluded. Thus while area under principal crops excluding rice at the national level was 71 per cent of the gross cropped area, the same crops covered only three per cent of the gross cropped area of Kerala state during 1982-'83.

The cropping pattern in Kerala is dominated by a different set of crops which are not widely found in other parts of India. In 1982-'83, 59 per cent of the gross cropped area of the state was collectively under a set of crops which included tapioca, banana, coconut, arecanut, pepper, rubber, ginger, cardamom, tea, coffee, cashew and cocoa. None of these crops appear as

principal crops at the national level. These crops, most of them perennials, are raised in the garden lands and dry lands of the state. Rice which occupied 27 per cent of the gross cropped areaduring 1982-'83 is raised in the wet lands, variously during the three seasons in an year. There is growing tendency to convert wet lands into garden lands wherever physically possible, which points to the declining importance of field crops, particularly rice. Rubber, cardamom, tea and coffee are plantation crops raised on large scale, mostly in the hilly tracts of the state. Cashew is found in the poorer soils mainly in Cannanore, Malappuram and Palghat districts. Coconut, arecanut, tapioca, banana, pepper and cocoa are raised both as pure crops and as a mixture, as is the common practice, on the innumerable homestead farms in the state.

Besides the cropping pattern, the average size of holding offers another point of contrast between the agricultural sectors at the national and state level. In 1976-'77, the average size of holding in the state was 0.49 hectare, while the all India average was 2.00 hectares. During the same year, the percentage of gross area operated by small and marginal farmers to the gross area operated by major size classes stood at 62 per cent and 24 per cent at the state and national levels respectively.

In view of these distinct features of the state's agriculture,

measures, both at the farm level and the regional level, to increase profitability of farms, need to be designed specifically with these peculiarities in mind. At the farm level, apart from the adoption of sound management practices and crop tending, the choice of crop combination and the optimal use of various resources, determines to a considerable extent the profitability of individual farms. If resources including land are being used sub-optimally, readjustments in the existing cropping pattern and resource use may be necessary for increasing farm income. Inclusion of dairy enterprises, which does not compete for land to any significant extent, has been observed to increase farm income. In addition there is the fact that farm labour is becoming a relatively scarce and costly input. Optimal distribution of such scarce resources among competing enterprises is a necessary condition for improving profitability of the farm.

Evolving such suitable crop combinations for different farm situations in Kerala, however, pose different problems. These are directly related to the peculiar cropping pattern found in the state, with the predominance of perennial crops and mixed cultivation mostly in the garden lands. Although many studies have attempted optimization of seasonal crop combinations with and without integration with livestock, studies relating to enterprise combinations on garden lands, and that too under the cropping condition of Kerala are scanty.

It would, therefore, appear worthwhile to study the various existing crop and livestock combinations found in the state and to develop optimal economic plans for broad categories of holdings which would help increase their value productivity. This study is therefore, expected to throw light on an area hitherto less explored and help in better understanding of the potentials for increasing farm profitability and income. The specific objectives of the study may be listed as follows:-

1. To understand the existing pattern of crop mixes with or without livestock enterprises in the study area.

2. To understand the extent and intensity of use of resources on the major categories of holdings.

3. To identify the major constraints in the production process.

4. To develop optimum farm plans for major categories of holdings for efficient use of resources to increase farm income.

The study is presented in five chapters including introduction. In the second chapter, a review of literature relevant to the study is given. The materials and methods of the study are discussed in chapter three. Chapter four contains the results and discussion and the methods and findings are summarised in the fifth chapter.

Review of Literature

REVIEW OF LITERATURE

The literature relevant to the study are presented in this chapter under three sections. In the first section studies of an introductory nature are discussed. Section two contains review of studies on optimization at the farm level. Finally, studies at the regional and national level are presented in the third section.

1. Introductory studies

Reviewing literature on the use of optimization methods in agricultural economics, Day and Sparling (1977) found that the principle dates back to 1826 with the concept of gain and loss at the margin developed by Von Thunen, who used it "to develop a theory of relative economic value and spatial diversity in the use of land, labour and capital".

One of the earliest tools of optimization, still in vogue is budgeting. Budgeting as a management tool using a balanced blend of analytical reasoning and careful empirical observations, was developed by agricultural economists in the United States during the first quarter of this century. In its most developed form, budgeting has served as an -

> "explicit arithematic procedure for obtaining approximate optima of simple constrained optimization problems and for exploring the broader implications at the regional and national levels of economic behaviour in response to changing economic conditions and policy controls"-

Day and Sparling (1977).

At the micro level, farm budgeting, according to Johl and Kapur (1973) is essentially "a method of analysing plans for the use of agricultural resources at the command of the decision maker". While a farm budget may be prepared merely to compare the cost and returns resulting from the adoption of a new method, or the use of new equipment, it may also be used, according to Yang (1965), to determine the prospective expenses and income resulting from a complete change in the choice and combination of farm enterprises and a complete reallocation of farm resources.

According to Day and Sparling, budgeting era may be said to have reached its culmination in 1951, with the introduction of modern optimization methods that year. In 1951, Hildreth and Reiter came up with the first specific application of modern optimization to agricultural economics, through their study on the choice of a crop rotation plan. This was followed by a series of studies dealing with various aspects and specific cases of the application of optimization techniques in agriculture, mainly in the United States.

In King's (1953) paper on applications of activity analysis in agricultural economics, he outlined four different techniques for analysing the situation where, the administrator of a given bundle of resources must decide what the proper combination of these resource inputs should be, and what bundle of products he should produce in order to maximize money profit. These

included (1) use of budgets, (2) mathematical estimation of the complete production functions, cost functions and revenue functions, (3) estimation of isoproduct contours for particular segments of the surface to which releative price lines may be applied to determine the optimum combination and (4) use of activity analysis to select the best combination.

Swanson and Fox (1954) made a comparative study of conventional budgeting and activity analysis as tools for selecting most profitable plan for a particular farm situation, and concluded that the latter provides a more powerful technique by increasing the range of alternative plans that might practically be considered.

Heady (1954) discussed various opportunities for using linear programming technique, and gave simple presentation of computational techniques with empirical examples.

McCrokle (1955) made a detailed comparative study of linear programming with marginal analysis and budgeting procedures. He found that, the technique could be applied successfully to four types of problems namely (1) cost minimization in producing a given output, (2) resource allocation among alternative lines of production, (3) determination of optimum level of factor input and (4) optimum resource use through time, and selections of alternative programmes for resource development.

In one of the earliest expositions on linear programming technique in India, Chakrabarthi (1958) discussed and illustrated with examples the usefulness of this technique in various spheres of the economy like (i) cost minimization in transportation, (ii) the diet problem and (iii) problems of profit maximization in agriculture.

Swanson (1961), after studying the practical application of linear programming in agricultural production, concluded that the operational advantage of linear programming over traditional marginal analysis in total farm planning stems chiefly from the fact that its data requirements more closely correspond to the kinds of information usually available for planning.

2. Farm level studies

Peterson (1955) presented a programming model in which the livestock enterprise and crop rotation are selected simultaneously. Using the technique, he maximized the returns to labour, capital and management by an appropriate combination of the livestock enterprises and crop rotation on a 240 acre farm.

In his study Desai (1960) sought to maximize farm business income under the constraints of land, capital and labour on each of four farms drawn as a sub-sample from 160 farms in the erstwhile Bombay state.

Dhondyal (1960) studied the application of farm management principles in planning and budgeting for eight holdings in the Kalyanpur extension block in Kanpur district. He found that programming led to a crop plan which increased the net income of a farm, and also provided additional opportunity for employment to the family labour through the intensity of culture and greater volume of farm business.

Kahlon and Johl (1962a) tested the potentiality of budgeting and linear programming by analysing specific farm situations in the Jodhar village of Ludhiana district in Punjab. The problem consisted of nine enterprises with 16 constraints. The total returns to fixed resources estimated through programming was Rs.6,951.21 as compared to Rs.6,166.94 estimated through budgeting.

Malya (1962) prepared optimal plans for two seasons with five and four crop activities respectively for a farm in Vadamalapuram village of Ramanathapuram district, Tamil Nadu. In both the seasons, with the resulting reorganized cropmix, net income was found to increase significantly.

The major objective of a study by Kahlon and Johl (1962b) was to find the most profitable rotation system that allowed for complementary relationships. The optimum solution was found in a combination of rotations rather than a particular rotation.

Sahni and Johl (1967) estimated the optimum combination of different vegetable crops so as to maximize the returns to fixed farm resources and to work out the marginal value products of different farm resources. The optimal rotations included potato, tomato, cauliflower and cabbage as vegetable enterprises. On the whole it was found that vegetable cultivation was risky and required heavy capital.

Sirohi and Gangwar (1968) worked out optimal plans under different situations-with and without capital restrictions, reorganization with and without inclusion of vegetable and dairy enterprises, and under conditions of existing and improved technology-for selected farms in the Nanjhawala block of the Union Territory of Delhi. The results of various optimal plans indicated a substantial potentiality for increasing net returns from the farms under proper allocation of resources. Inclusion of vegetable crops in plans along with unrestricted borrowed capital stepped up the farm net returns on all sizes of farms but more on small farms.

Dhawan and Johl (1969) in their study conducted with the twin objectives of locating the price of milk at which dairy enterprise would start paying in comparison with crop cultivation and finding the levels of dairy enterprise in the production programme of the farmers at different levels of milk price, found that a price of Rs.0.77 per litre at 1964-'65 relative price level was the minimum price essential to

incorporate dairy activity in the farmers production plans.

After a case study of the production patterns in the Union Territory of Delhi, Guglani and Sirohi (1972) concluded that dairy enterprise was profitable and could be included as a complementary enterprise along with crops to increase farm income.

Arora and Prasad (1972) developed optimum models for small, medium and large farms under two situations of existing technology with and without borrowing. From the findings of the study it was observed that the combination of maize and/or paddy with wheat crop should be grown on maximum possible area of the Meerut district.

Singh et al. (1977) examined the impact of integrated crop and milk production on small farms in Punjab, and observed that a maximum increase of about 110 per cent in farm incomes was possible when one improved buffalo and three improved cows were introduced in the plan with improved crop technology. The percentage increase in farm income under different situations indicated an increasing trend with the level of dairy enterprise under both existing and improved technology.

Shanmugam (1979) developed optimum plans at existing resource levels for maximizing income and employment in farms in the Annur block of Coimbatore district, Tamil Nadu. The optimum plans revealed that the net returns could be increased

by 38 per cent on small farms and 21.64 per cent on marginal farms even by reorganizing the existing resources.

Sirohi et al. (1980) worked out optimum farm plans at two levels of cash availability, and three levels of mixed farming viz. crops, crop plus dairy, and crops plus dairy plus poultry, for various sizes of farmsin the Kanjawala block, Union Territory of Delhi. Their observations included the possibility of increasing returns on small and marginal farms in the area through better combination of crop, livestock and poultry enterprises. The small and marginal farmers stood to benefit very much by introducing poultry enterprises.

3. Regional and national level studies

3.1 Block or district level studies. Nine crop rotations were considered by Johl and Kahlon (1963), to determine the highest return cropping pattern suited to Ludhiana development block in Punjab. A comparison of existing cropping pattern with the optimum cropping pattern with capital restrictions revealed that there was only a slight increase in returns to the fixed resources. However, the study showed that when capital borrowing activities were added, there was a marked increase in net returns in the optimum cropping system.

Johl and Kahlon (1966) studied labour utilization patterns and employment potentials on farms in the Pakhowal block of Ludhiana district, Punjab. After analysing the labour availability, utilization and balances, under existing

techniques of production as well as after introduction of improved production techniques on a synthetic farm situation in the study area, the authors concluded that there existed serious imbalances in agricultural labour supply and its use on the farms in the study area. Although these imbalances were likely to increase if resource use was rationalized through judicious farm management decisions at the existing level of production techniques, improved production techniques accompanied by rational farm management decisions were found to improve labour utilization and generate more gainful employment potential.

The results of a study on the comparative profitability of dairy enterprise in relation to crop cultivation on suburban farmsin Punjab, undertaken by Dhawan and Johl (1967) indicated that maximum percentage gain in net returns in optimal plans were in small farms; an increase of 102.8 per cent. The inclusion of dairy enterprise was found to lead to a reduction in income. However, commercial dairy enterprise had the potential to ensure a regular flow of income throughout the year.

Role of commercial crops in enhancing farm income was studied by Chauhan et al. (1974), in the Jaipur district of Rajasthan. Two alternative optimum plans were developed to examine the possibility of increasing farm incomes from commercial crops. The results of the two optimum plans indicated

clearly that there existed a significant scope for increasing incomes on farms of all sizes through the adoption of commercial crops.

Sivaprakasam (1974) derived optimum plans for resource use and income efficiency on four different farm situations in Pattukkottai division, Thanjavur district, Tamil Nadu. He recorded percentage increases in net income for optimal plans over the existing plans, ranging from 22.64 per cent in situation two, to 72.26 per cent in situation one, and a maximum increase of nearly cent per cent in situation four.

The general objective of a study by Balasubramanian (1975) in Dindigual division of Maduri district, Tamil Nadu, was to assess the resource use efficiency on garden land farms and to formulate optimum crop plans for three farming situations in the area. The optimal plans indicated significant increases in net incomes in all the three situations: 61.27 per cent in situation one, 57.90 per cent in situation two and 24.15 per cent in situation three. The total labour utilization also increased in all situations: 26.40 per cent, 19.64 per cent and 4.71 per cent respectively in situations one, two and three.

Sirohi and Sharma (1978), after studying farm planning under fertilizer constraint in the Alipur block of the Union Territory of Delhi observed that the positive effect of resource optimization and multiple cropping were several times

greater than the absolute negative effect of reduction of fertilizer on farm returns.

Based on the study of farmers in selected villages in Aligarh district of Uttar Pradesh, Pandey and Bhogal (1980) showed that incomes could be increased by introducing dairy through high yielding buffaloes particularly on small farms and with better crop combinations on large farms. The optimal plans worked out by them utilized labour more efficiently.

Muthusamy (1982) studied optimization of resource use in garden land farms in Namakkal block in Salem district of Tamil Nadu. The results of his study showed that the optimum crop plan included only less water consuming crops such a cotton, groundnut and cholam. Tapioca, even though an annual crop, found a place in the optimum plan since it required less water.

3.2 State level studies. Sadasivan and Rai (1967) prepared a plan for allocation of cultivable land among the different economic crops of Kerala State, subject to a set of four conditions. The results indicated that overall, by reallocation as recommended, net income would increase by more than 19 per cent. In the optimal programme, the area under paddy, coconut, pepper, cardamom and coffee declined whereas area under arecanut, tapioca and tea showed significant increase.

Restrictions of land, human labour, bullock labour and

cash were considered by Singh et al. (1972), in their study conducted in three regions of Utter Pradesh. Optimum cropping patterns with limited and unlimited cash were formulated for the three regions and compared in each case with the existing patterns. The results clearly demonstrated that under the existing cropping patterns, farm resources were not utilized optimally on the small farms of all the three regions. A clear implication of the study was that even with limited cash resources available with the small farmers, a change in the cropping patterns would positively enhance the existing farm incomes.

The increasing emphasis on production per unit of cultivation and per unit of time may compell farmers to gradually mechanize their farms and drastically reorganize the crop mix. Sharma and Kahlon (1972) studied normative shifts in cropping patterns in Punjab as a result of these changes, and concluded that income bright crops such as American cotton, sugarcane and groundnut would replace less profitable crops like desi wheat.

The prospects for regional specialization in the cultivation of commercial crops was studied vis-a-vis the objective of regional self-sufficiency in food grain production, in Punjab by Sankhayan and Sidhu (1974). The programmed solution to this problem showed substantial changes in the cropping pattern with a marked decline in area under food grains. In the solution, food grains accounted for only 74.69 per cent of

the total cropped area, as compared to 80.37 per cent in the existing plan. The authors concluded that a policy of regional self-sufficiency in food grains, accompanied by optimum allocation of scarce resources might help in increasing the aggregate value product by 5.63 per cent in Punjab state alone.

Optimum plans developed by Dhawan and Kahlon (1975) for small, medium and large holdings in the central plains of Punjab indicated marked shift in production patterns when compared with the existing ones. Maize - potato - wheat - green gram came out to be the most paying rotation in both the regions of the central plains of the state.

Singh (1977) attempted to outline a strategy for integrated use of land and other resources in the hill regions of Utter Pradesh. Besides studying the existing crop pattern and input use rates, the study explored the possibilities of increasing farm income and employment by optimum resource combination, by developing six, alternative optimum plans. The highest increase in returns over variable costs was possible under the sixth plan which envisaged the use of improved crop technology, alongwith milch animals, and poultry and relaxation of credit constraints.

In a study aimed at formulating optimal farm plans in different agro-climatic zones of Himachal Pradesh, Nadda et al. (1978) noted that cereal crops dominated other crops in respect of area and net returns in the low hills whereas the

reverse was found true in the mid hills for both the existing and optimum plans. The study also indicated the existence of surplus labour in the hilly areas which, according to the authors, suggested the need for promoting agro-based industries in the area to absorb the excess labour force.

Optimum plans developed by Mruthyunjaya and Sirohi (1979) for representative farms in the drought-prone tracts of Karnataka were found to give farmers higher net returns at a lower level of risk. Increased use of crucial inputs like credit and bullock labour, while increasing net returns were also found to add some instability to the enterprise system. On the other hand, mixed farming not only increased net returns on farms, but added stability to the system.

Stewart et al. (1979) studied a group of farmers in the Kentucky area in the United States, and observed that even with the existing farm management practices, farm incomes could be increased if sufficient capital was made available.

The crucial role of capital in changing the existing cropping pattern on different sizes of farms was brought out clearly in a study by Patel and Gangwar (1983). While estimating the potential for the farm income and employment in the dry farming areas of Haryana, the authors found that profits on all size of farms could be increased considerably by making the required capital available.

3.3 National level studies. In a major study on spatial programming of production for agricultural development in India, Randhawa and Heady (1966) employed an interregional programming model, to determine the optimum allocation of acreage among competing crops and regions. The model was formulated using up to 467 equations and variables, and considered regional land constraints, comparative advantage of different regions for various crops and an array of constraints. The model solutions suggested some important increases in production and incomes, if land were allocated by regions and crops as specified by the results. About 12 per cent gains could be realized entirely from a reallocation of crop production to conform with regional production possibilities and comparative advantage.

Onyenwaku et al. (1982), attempted to illustrate how a linear programming model could be used in planning the desired national self-sufficiency in food production. For this the authors developed a spatial linear programming model for Nigeria, comparing 80 real activities and 84 constraints. The three alternative goals listed were, national self-sufficiency in food grain production in (i) 1977-'78, (ii) 1979-'80 and (iii) 1984-'85. Authors recommended the adoption of the methodology of the study to the planning of other sub-sectors of the country's agriculture.

3.4 Other studies. Singh and Sirohi (1976) developed a model with 668 crop processes and 264 constraints to work out economic optimal pattern of distribution of available water supplies of Upper Ganga canal for maximizing returns to irrigation water in the command area. Of the two optimal plans prepared, plan I without optimal allocation of canal water among the various branch canals resulted in a combined increase of gross return in all regions amounting to 16.4 per cent over the returns in the existing plan. In the optimal plan II with optimum allocation of canal water, the total returns in the command area as whole increased by 24 per cent.

McCarl et al. (1977), have discussed the design for direct use with farmers, of a linear programming model for farm planning called "Purdue Top Farmer Cropping Model 'B'". The model was run with 5000 farmers. The authors have stated that success of the model was due to its design and the interplay between research and extension personnel in the model design.

Norton et al. (1980) used a multi-year linear programming model to assist an American Indian tribe develop agricultural plans for their tribal farm. Five year crop, live stock and investment plans were generated consistent with the tribal resource base, goals and decision making structure.

Calkins (1981) showed that linear programming can help

plan rural development, if the income maximization and least-cost diet models are integrated within the resource and management limitations of small-scale representative farms. Through six model formulations of a representative Nepalese farm, linear programming was used to identify the most nutritious and profitable production pattern; trade-offs between nutrition and income; and the costs of constraints relating to levels of credit, market availability, and human capital development.

Thamodaran et al. (1982) analysed effects of alternative output and input price situations on the choice of output and input levels, including water management systems, in their study in Southern Tamil Nadu. The authors concluded that under the existing resource constraints, a farmer in the study area should bring all his land into the silt system of irrigation with banana as a major crop to maximize profits.

Materials and Methods

MATERIALS AND METHODS

The materials and methods of the study are described in this chapter under five sections. Section one contains a brief description of the study area. Procedures followed in sampling and collection of data are discussed under sections two and three respectively. Section four contains a discussion on the principal features of the sample. In the fifth section, a detailed discussion on the method of analysis is given.

1. Description of the study area

The area of study comes under the Panancherry panchayat of Ollukkara development block in Trichur district. The panchayat occupies a total geographical area of 57.6 square kilometers and is divided into 13 wards. The total population according to the 1981 census was 28,500.

There are two high schools, three upper primary schools, two lower primary schools and two government tribal lower primary schools in the panchayat. The dairy enterprise in the panchayat is served by six milk societies, viz: Alpara, Peechi, Vaniyampara, Vazhukkumpara, Pananchery and Chevannamannu. In addition, there is a veterinary hospital and two integrated cattle development project sub-centres functioning at Kannara and Vaniyampara. The panchayat has a service co-operative bank (Register Number: 541). The Agricultural Development Unit serving the Madakkathra,

Ollukkara and Panancherry regions is also located in the panchayat.

Of the 6660 farm families in the panchayat, 76 per cent (5058) possessed holdings of size up to one hectare (2.5 acres). Twenty two per cent of families (1476) had holdings between one and three hectares (2.5 to 7.5 acres), and only two per cent (126)had holdings above three hectares (7.5 acres). Twenty nine per cent of holdings under one hectare had sizes of only up to 0.1 hectare (0.25 acre). Distribution of farm families according to size of holding is given in Table 3.1.

Table 3.1 Distribution of farm families in Panancherry panchayat, according to size of holding (1983-'84).

Size of holding (hectares) 1	Number of farm families 2	Percentage to total 3
0-0.1	1475	22.15
0.1-1.0	3583	53.80
1.0-3.0	1476	22.16
Above 3	126	1.89
Total	6660	100.00

Source: Agricultural Development Unit, Panancherry.

The major crops grown in the area were paddy and pulses as field crops, coconut, arecanut, banana, pepper and tapioca

as garden crops and rubber and cashew as dry land crops. The cropping pattern in the panchayat is given in Table 3.2. The staple food crop, paddy was grown in a net area of 883 hectares (2207.5 acres) which constituted 33 per cent of the gross cropped area of 2688 hectares (6720 acres). The gross area under paddy stood at 1653 hectares (4132.5 acres), this being the aggregate of the three cropping seasons, viz: virippu, mundakan and punja with 641 hectares (1602.5 acres), 757 hectares (1892.5 acres) and 255 hectares (637.5 acres)

Table 3.2 Cropping pattern in Panancherry panchayat for the year 1983-'84.

Crop (1)	Area (hectares) (2)	Percentage to gross cropped area (3)
Rice	883	32.85
Tapioca	660	24.55
Coconut	390	14.51
Arecanut	198	7.37
Banana	125	4.65
Cashew	105	3.91
Rubber	91	3.38
Pepper	70	2.60
Pulses	36	1.34
Others	130	4.84
Total	2688	100.00

Source: Agricultural Development Unit, Panancherry.

respectively. Area under tapioca, at 660 hectares (1650 acres) constituted 25 per cent of the gross cropped area. Coconut

was cultivated in 390 hectares (975 acres) which was 15 per cent of the gross cropped area. Arecanut and banana occupied 198 hectares (495 acres) and 125 hectares (312.5 acres) respectively, which works out to seven per cent and five per cent of the gross cropped area. Rubber plantations, mainly on hill slopes around Veniyampara, occupied an area of 91 hectares (227.5 acres), while cashew raised on poorer and dry soils covered 105 hectares (262.5 acres).

2. Sampling procedure

The characteristics looked for in the sample cultivators were the cultivation of a mixture of major garden crops, this being the more common pattern in the state, and availability of irrigation facilities during summer. After discussion with the technical experts of the Agricultural Department, the ninth ward of the Panancherry panchayat was purposively selected as the study area. A list of farmers with a minimum of 50 cents (0.5 acre) of garden land constituted the frame from which a random sample of 75 farmers were selected, using a random number table.

3. Collection of data

Data for the study were collected from the sample holdings by the personal interview method using a well structured schedule covering all aspects relating to the inputs and outputs of crops and dairy enterprise. Specimen of the

schedule used is given in Appendix-I. The information collected included the total size of holding, total area under garden crops, area under individual crops or plant population as in the case of perennial crops, details of quantity and value of inputs used and outputs obtained from each crop and similar details for the dairy enterprise. The reference period for the study was the agricultural year from June 1, 1983 to May 31, 1984.

4. Principal features of the sample

4.1 General. Out of 75 farms constituting the sample three were rejected owing to extremes of values and lack of irrigation facilities. No attempt was made at substitution and the remaining 72 farms formed the ultimate sample. Based on the size of garden land holdings, the sample was categorised into four groups as shown in Table 3.3.

Such a classification was resorted to as the nature of farming decisions of these groups differed considerably from one another in terms of types and amounts of inputs used, capital availability and other physical and monetary constraints. Rest of the analysis was done for each of these categories separately.

The average sizes of the various categories worked out to 0.99 acres, 1.85 acres, 2.96 acres and 4.46 acres respectively for categories I to IV, the aggregate average

Table 3.3 Categorization of garden land holdings according to area.

Category 1	Size of garden land holding (acres) 2	Number of holdings 3	Total area (acres) 4	Average area under garden land (acres) 5
I	0.50 to 1.49	27	26.75	0.99
II	1.50 to 2.49	25	43.13	1.85
III	2.50 to 3.49	10	29.58	2.96
IV	3.50 and above	10	44.58	4.46
Total		72	144.04	2.00

for the sample being 2.00 acres. The total area under garden crops covered by the study was about 144 acres.

4.2 Cropping pattern. The garden crops, particularly the perennials exist as a mixture without specific demarcation of area for individual crops. This posed the problem of delineating area under each crop separately for the different holdings. The number of plants of each crop in each holding was recorded. Banana, only Nendran variety of which was considered in the study, and tapioca were raised as pure crops. It was thus possible to record the area under them directly from the holdings in which they were grown. This detail, together with the total number of plants of each perennial crop separately as young, non-bearing and adult, bearing under each category of holdings is given in Table 3.4.

Table 3.4 Categorywise area/plant population under different crops.

Crops		Categories I	II	III	IV
1		2	3	4	5
Coconut (No.)	A	593	868	463	1015
	Y	526	1208	765	1290
		(42)	(48)	(42)	(52)
Arecanut(No.)	A	3600	4445	2850	3100
	Y	85	525	110	300
		(114)	(115)	(100)	(76)
Pepper (No.of standards)	A	595	380	270	330
	Y	85	120	60	90
		(25)	(12)	(11)	(9)
Cocoa (No.)	A	220	150	75	130
	Y	-	-	-	-
		(8)	(4)	(3)	(3)
Banana (Acre)		3.58	3.30	1.30	2.10
Tapioca (Acre)		1.05	1.13	1.03	1.00

(A - Adult and Y - Young; figures in parenthesis show average crop population per acre)

4.3 Dairy enterprise. Many households in the sample possessed some livestock like cattle, buffaloes and/or goats. In this study data were collected only from those households producing cow milk, as production of buffalo and goat milk was insignificant. There were principally two types of cows, viz: local and cross bred as shown in Table 3.5. As can be expected, over 63 per cent of cows were with those farmers

having holdings with size less than 2.5 acres; a result of the aids extended to small and marginal farmers through development projects for supplementing farm income. About 77 per cent of cows were cross breds.

Table 3.5 Distribution of cows in milk among different categories of holdings.

Categories (1)	Types		
	Local (2)	Cross bred (3)	Total (4)
I	4	8	12
II	1	6	7
III	1	5	6
IV	1	4	5
Total	7	23	30

5. Method of analysis

One of the specific objectives of the study was to determine the optimum combination of crops and milk production, that would maximize net farm income subject to resource availability under the existing conditions. In order to arrive at this optimum enterprise combination, linear programming technique was used as the analytical tool. The technique involves the formulation of a set of inequalities subject to which an objective function is to be maximized. The linear programming model used was of the following form:

Maximize $Z = CX$

Subject to $AX \leq B$

and $X \geq 0$

where X = level of activity

C = net income per unit of activity (net margin)

A = input per unit of activity (input coefficient)

B = input availability

Programming matrices are made up of the objective function CX and the technological matrix AX and vector B. Four such matrices were prepared, one for each category of holdings. These were then solved with the aid of computer. The preparation of objective function and the technological matrix for each category was done through a series of steps as described below.

5.1 Selection of representative farms. Optimal enterprise combinations had to be worked out for four model farm situations selected one each from the four categories of holdings. For the selection of a model farm from a category, the garden land area on farms in the category was first listed. From this list modal sized farms were identified. Then the resource position on the modal sized farms were examined and one representative farm was chosen from each category. The criterion followed in this selection was that the selected farm should be fully representative of the farms

and the farming conditions in that category so that the combination worked out for it is applicable to other farms in the category.

5.2 Selection of activities. In order to develop optimum crop plans, it is necessary to identify activities which are technically feasible and suited to the study area. Six crops almost wholly dominated the cropping pattern in the garden lands of the sample farms. These were coconut, arecanut, pepper, cocoa, banana and tapioca. In addition, a sizable number of farmers had dairy enterprise also. Fodder cultivation to support dairy enterprise was not observed on any of the farms. Thus, dairy enterprise competed with crop enterprises in respect of two inputs only, viz: capital and labour. A notable aspect in the cultivation of pepper and arecanut was that they were raised as a single enterprise with respect to land utilization, with pepper vines trained on the arecanut palms. As such arecanut plus pepper was considered in this study as a single enterprise.

5.3 Resource availability and constraints. The problem of determining an optimum enterprise combination exists only when the resources are limited, and within this limitation, given objective function is to be maximized. In agriculture, as Singh (1971) has stated, the main resource constraints may be

> "different qualities of land, seasonal labour supply, animal and mechanical power, fertilizers and chemicals, finance, behavioural constraints such as consumption goal, flexibility and adoption constraints and technological constraints".

After examining the resource position, the following were identified as the limiting factors in the present study, viz: land, labour availability during three agricultural seasons: June to September, October to December and January to May, availability of irrigation water and working capital. For the formulation of programme matrix, it is necessary to estimate the level of availability of each of these six constraints. The amounts of these resources used on the model farm selected from a category were taken as the level of resources available in the matrix for that category.

(i) Land. Type of land available in the study area could be broadly classified as wet land, garden land and dry land. In this study only garden land has been considered and the area selected being compact, the units were homogenous.

In the estimation of available garden land on the typical farms selected, the area occupied by young and non-bearing plants of crops cultivated had to be excluded. This is because while non-bearing plants entailed maintenance expenditure, they did not add to the income of the farm. The programming was done for one year period, assuming that all the activities included contribute to the income of the farm. This resulted in the need to consider, primarily, the bearing plants among the perennial crops for estimating area occupied. The broad guidelines of spacing recommended by Kerala Agricultural University were used in estimating area subject to the existing total area and plant

density. To this estimate, the area under banana and/or tapioca, which could be directly recorded since they were raised as pure crops, was added to get the size of total available garden land for the respective category of holdings.

(ii) Labour. The utilization of labour on the sample farms could be broadly divided into three seasons viz: South-West monsoon season from June to September, North-East monsoon season from October to December and summer season from January to May. The labour available during these three seasons on the model farms constituted the levels for the three different labour constraints. During the survey, it was observed that almost all the farmers used a mixture of family and hired labour for various operations on the farm. Separation of the family and hired components of total labour that went into an operation was found very difficult. Therefore, no attempt was made to separate family and hired labour used on the farm.

Valuation of labour was done at rates paid out on the sample farms during the period of survey. In the technological matrix, labour was accounted in man hours. Standardization of female labour was done using the wage ratio of male to female labour.

(iii) Irrigation. All the farmers in the sample had facilitated irrigation of their lands. Those who did not have their own facility, hired irrigation water from neighbours who possessed such facility. In the calculation of cost of cultivation, cost

of irrigation water was accounted for, by using the prevailing rate at which an hour of custom irrigation from a standard three horse power pump set was available in the area. The total hours of irrigation used up on the model farms during the period of study constituted the level of irrigation constraint for the respective category of holdings.

(iv) Capital. Working capital exerts considerable influence on the pattern of resource use on the farm. When the capital position is tight, some important cultural operations like fertilizer application are reduced or omitted. Input use usually increases when capital is sufficient. The amount of working capital utilised on the model farms during the entire one year period was taken as the restriction level. Items included under working capital were expenditure on seed material, fertilizers, organic manure, pesticides, labour charges and propping charges for crop enterprises and feeding and maintenance, veterinary services and milking charges for dairy enterprise.

5.4 Input coefficients. The input coefficients of the technological matrix are resource requirements per unit of the activity. Desai (1963) suggested that the best estimate of input coefficients would be the average of input use obtained over the samples in a category. On similar lines, in the present study, the input coefficients were calculated by taking the average of a resource used for each activity in

each category and computing the quantity per unit of activity. Input coefficients for arecanut and pepper, which were together taken as one enterprise for programming, were worked out separately. For those farms which actually grew arecanut and pepper as one enterprise, the total use of each resource was apportioned between arecanut and pepper according to the ratio of the value of their products on the particular farm. Input coefficients thus worked out separately for each resource was added up to get the coefficient for the combined enterprise.

5.5 Net margins. For stating the objective function, it is necessary to have the net margins or the net income per unit of activities. Calculation of net margins of activities with one year duration is relatively easy. First total variable costs for activity on each farm was determined and deducted from the total returns from it on respective farm, to get the net returns. The net returns for the activity on each farm in a category were added up and from this, the average net return per unit of activity was worked out. For cow activity, categorisation was not attempted, and therefore, the net returns from all farms were added up and divided by the number of cows in milk to get the net returns per head of cow. With regard to perennial crops, the variable costs incurred during an year represent only the maintenance expenditure. The net income for an year from an adult plant cannot be considered as the returns for that year alone, because a part of it is the

returns to investments made earlier. Thus, unlike annual crops, the problem of investment in perennial crops demand consideration in depth, because of their longer economic life span, and the fact that several years must elapse after planting, before any returns are obtained from them.

The problem of net margins for perennial crops was solved in this study by calculating the average annual net present worth. George and Joseph (1973) have calculated average annual net present worths for coconut, rubber and oil palm. The distinct advantage in calculating average annual net present worth of perennial crops is that it facilitates comparisons of returns not only among perennial crops with different economic life spans, but also of returns between annual and perennial crops. In the present study average annual net present worths were calculated for each perennial crop activity separately for each category of holdings. The procedure followed is discussed below.

The net present worth was calculated using the formula

$$\text{Net Present Worth} = \sum_{i=1}^{n} \frac{R_i - C_i}{(1 + r)^i}$$ where

n = economic life period

C_i = gross cost for ith year

R_i = gross return for ith year

r = discount rate

Net present worth was calculated for each crop, separately for each category of holdings. Whenever farms in a category did not have a crop, or when the total plant population of a crop was very small for a category, the net present worth for the crop in the immediately preceeding category was used.

The explanation and method of calculation of each item in the expression for net present worth, is given below.

(i) Economic life period. Each crop enterprise has an economic life period, beyond which the net returns when discounted to the base year would be insignificant or negligible. The costs and returns were estimated for each year for the entire economic life span of the crop using the data generated from the study. The economic life period for the four crops were fixed after consultation with technical experts as follows:

Coconut and arecanut - 40 years;

Pepper and cocoa - 20 years.

(ii) Discount rate. The discount rate used in the calculation was nine per cent which is the interest rate at which credit is available as long term loans for investment in perennial crops.

(iii) Cost flows. The costs incurred during the economic life period of a perennial crop may be divided into three distinct stages. Initial investment for planting the crop

includes expenditure on such items as preparation of land, purchase of planting material and planting itself. The second stage of costs consists of maintenance charges during the period upto the year of bearing. In the third stage costs are made up of maintenance expenditure incurred from the year of first bearing to the terminal year of economic life. This third stage of cost flow may be assumed to be uniform if maintenance practices and unit value of inputs remain unchanged.

In the present study only cross-sectional data for the costs in the third stage was available. From this data, the cost flow for an acre of each crop was estimated, separately for each category of holdings. This was done by first calculating the average cost incurred for a mature yielding plant of each crop in each category, and then multiplying this figure by the density of the crop per acre. Data on initial investment expenditure and maintenance cost up to the year of bearing was not directly available and was estimated in consultation with experts on concerned crops, using cross sectional data on adult plants as the guideline.

(iv) Flow of returns. Returns from a perennial crop starts from the year of bearing, gradually increases with increase in yield, then stabilizes as does the yield, and remains so till the end of the economic period. The flow of returns from unit area of a crop from the year in which yield stabilizes to

the terminal year of economic life, may be considered uniform if it is assumed that the maintenance practices and the unit value of the output from the crop remain unchanged during this period. This flow was estimated for an acre of each crop separately for each category by finding the average returns per plant and then multiplying this figures by the estimated density of the crop per acre. The flow of returns from the year of first bearing to the year in which yield stabilizes, on which data was not directly available, was estimated in consultation with experts on concerned crops, using cross sectional data on adult plants as the guideline.

The flow of costs and returns over the economic life period of each crop for each category, were then discounted to their present worths by the expression cited earlier. The net present worths were determined by deducting present worth of costs from present worth of returns. The net present worth of future margins determined in this way may be assumed to represent a constant annual return over the economic life of the crop. This average annual margin was calculated by dividing the annuity factor for 'N' years at the discount rate 'r', into the net present worth. This average annual net present worth was used in the present study as the net margin of the respective crop under the particular category.

5.6 Prices and units used. For the calculation of costs and returns, it is necessary to have an accurate record of the prices of inputs and products. In the present study, the actual prices of inputs and products paid and received by the

farmers during the period of survey were used.

All activities included in the programming were defined per acre of land. The dairy enterprise was determined per head of adult cow in milk yielding 1214.7 litres of milk during the year. The categorization of holdings was also done on an acre basis. The net margins of crop activities were defined per acre of the crop.

5.7 Study of optimal plans. The optimal enterprise combinations worked out for each category of holdings, were studied in comparison with the existing plans on the model farms, with respect to changes in land allocation, utilization of resources and changes in net farm income. The net income on each model farm under the existing condition was determined by adding up the net incomes from each activity in the existing plan. For perennial crops, the net returns for the year could not be used, and therefore, net income was estimated by multiplying the number of yielding plants with the net margin per plant for the category. The sensitivity of the optimal plans was tested by considering suitable changes in the prices of outputs of some of the activities.

5.8 Limitations of the study. The limitations of the study arise from its regional nature, possible recall errors in the data, and the fact that period of the study was a single year, whereas some crop activities were perennial. The study was conducted

using data under the existing conditions, collected from a small region. Any attempt at generalisation, therefore, should be done with care. Similarly, since farmers did not maintain any records, they provided the data from recall. As such, data is likely to suffer from certain degree of recall error. Further, because perennial crops are involved, optimal plans can be taken only as guidelines to the most profitable enterprise mix to be evolved under the existing conditions and to understand the imbalances in the existing resource use pattern. Finally, the results of the study need to be interpreted keeping in mind the two assumptions of linearity and single value expectations, made while using the linear programming model as the tool of analysis.

Results and Discussion

RESULTS AND DISCUSSION

The results obtained in the study and the discussions thereon have been presented in six sections. The first section outlines the resource use pattern on the different categories of holdings and the input coefficients for the activities included in the programming. The second section contains the levels of the major constraints in each category of holdings. The net margins of the activities were worked out separately for each category of holding and these are presented in section three. The solutions to linear programming matrices set up, combining information from the above 3 sections are presented and discussed in comparison with existing plans in section four. Section five contains a discussion on resource utilization observed in the optimal plans. The sensitivity of optimal plans to possible changes in prices of some outputs has been discussed in the sixth section.

1. Input coefficients

The input coefficients for the activities under the four categories of holdings are given in Tables 4.1 to 4.4. The crop activities have been defined per acre (0.4 hectare) of land. The input coefficient of land in all cases therefore, will be one. For dairy enterprise, husbandary practices in maintenance and production did not differ appreciably over

different categories of holdings. Therefore, one set of input coefficients was considered sufficient for all categories of holdings. Further, as dairy enterprise did not compete with crop enterprises for land and irrigation, the input coefficients for these resources had zero value.

1.1 Category I. With respect to category I, it can be seen from Table 4.1, that banana had the highest input coefficients for all resources. Percentage utilization of resources ranged between 32 per cent of second season labour to 45 per cent of irrigation. Arecanut plus pepper had the next highest input coefficients, with percentage utilization ranging between 22 per cent of third season labour and 34 per cent of irrigation. Among coconut, cocoa, tapioca and cow activities a single ranking with respect to input coefficients for all resources was not possible. However, it can be seen that, of all activities, cocoa had the smallest input coefficients for all resources except irrigation, with percentage utilizations ranging between 4 per cent of capital and 9 per cent of second season labour.

1.2 Category II. Banana had the highest input coefficients for all resources followed by arecanut plus pepper. For former, percentage utilization lay between 33 per cent of second season labour to 51 per cent of first season labour. For latter lowest percentage utilization was for third season labour (18 per cent) and highest for irrigation (29 per cent).

Table 4.1 Input coefficients for first category of holdings (0.50 to 1.49 acres) (0.20 to 0.60 ha).

Resources	Activities						Total
	Coconut	Arecanut + pepper	Cocoa	Banana	Tapioca	Cow	
1	2	3	4	5	6	7	8
1. Land (acre)	1	1	1	1	1	0	-
2. Labour (man hours)							
a) June to Sept.	131 (11.1)	275 (23.3)	63 (5.3)	525 (44.5)	95 (8.1)	91 (7.7)	1180 (100.0)
b) Oct. to Dec.	84 (11.6)	187 (25.8)	64 (8.8)	230 (31.7)	92 (12.7)	68 (9.9)	725 (100.0)
c) Jan. to May	82 (5.4)	310 (22.4)	55 (4.0)	605 (43.8)	215 (15.6)	114 (8.3)	1381 (100.0)
3. Irrigation (hours)	45 (10.1)	151 (33.8)	28 (6.3)	199 (44.6)	23 (5.2)	0	446 (100.0)
4. Capital (rupees)	2490 (12.8)	4359 (22.4)	831 (4.3)	8300 (42.7)	1269 (6.5)	2190 (11.3)	19439 (100.0)

(Figures in parenthesis show percentage to total)

Table 4.2 Input coefficients for second category of holdings (1.50 acres to 2.49 acres) (0.60 to 1.00 ha).

Resources	Activities						Total
	Coconut	Arecanut + pepper	Cocoa	Banana	Tapioca	Cow	
1	2	3	4	5	6	7	8
1. Land (acre)	1	1	1	1	1	0	-
2. Labour (man hours)							
a) June to Sept.	111 (9.5)	222 (19.1)	53 (4.6)	591 (50.8)	95 (8.2)	91 (7.8)	1163 (100.0)
b) Oct. to Dec.	79 (11.6)	161 (23.7)	53 (7.8)	226 (33.3)	92 (13.6)	68 (10.0)	679 (100.0)
c) Jan. to May	57 (4.1)	246 (17.7)	53 (3.8)	704 (50.7)	215 (15.5)	114 (8.2)	1389 (100.0)
3. Irrigation (hours)	44 (9.0)	143 (29.2)	48 (9.8)	232 (47.3)	23 (4.7)	0	490 (100.0)
4. Capital (rupees)	2154 (11.4)	3489 (18.6)	558 (3.0)	9168 (48.7)	1269 (6.7)	2190 (11.6)	18828 (100.0)

(Figures in parenthesis show percentage to total)

Ranking of percentage utilization varied with each resource for other activities. Cocoa had lowest input coefficients for labour and capital.

1.3 Category III. It can be seen from Table 4.3, that banana had the highest input coefficients for all resources. The percentage utilization of resources lay between 34 per cent of second season labour and 58 per cent of first season labour. In this category, arecanut plus pepper had the next highest input coefficients for all resources except first season labour for which coconut had a slightly higher input coefficient. Cocoa continued to have smallest input coefficients among all activities, except for irrigation.

1.4 Category IV. In category four, banana and arecanut plus pepper had first and second highest input coefficients respectively for all resources. Like in other categories, cocoa had the lowest input coefficients for labour and capital. Percentage utilization of resources for cocoa lay between 3 per cent of capital and 9 per cent of irrigation. For irrigation, smallest input coefficient was for tapioca, percentage utilization being 6 per cent.

1.5 Conclusions. An examination of the pattern of resources utilization over all the categories revealed that banana was the most resource intensive of all activities in all categories of holdings. Percentage utilization of resources in all categories for banana was between 32 per cent to 58 per cent.

Table 4.3 Input coefficients for third category of holdings (2.50 acres to 3.50 acres) (1.00 ha to 1.40 ha)

Resources	Activities						Total
	Coconut	Arecanut + pepper	Cocoa	Banana	Tapioca	Cow	
1	2	3	4	5	6	7	8
1. Land (acre)	1	1	1	1	1	0	-
2. Labour (man hours)							
a) June to Sept.	106 (10.2)	101 (9.7)	34 (3.3)	608 (58.3)	102 (9.8)	91 (8.9)	1042 (100.0)
b) Oct. to Dec.	81 (11.6)	178 (25.5)	49 (7.0)	234 (33.6)	87 (12.5)	68 (9.8)	697 (100.0)
c) Jan. to May	64 (4.7)	243 (17.8)	59 (4.3)	660 (48.4)	224 (16.4)	114 (8.4)	1364 (100.0)
3. Irrigation (hours)	43 (8.5)	151 (30.1)	43 (8.5)	236 (46.9)	30 (5.0)	0	503 (100.0)
4. Capital (rupees)	2155 (12.3)	2291 (13.2)	501 (2.9)	8967 (51.3)	1364 (7.8)	2190 (12.5)	17468 (100.0)

(Figures in parenthesis show percentage to total)

Table 4.4 Input coefficients for the fourth category of holdings (3.5 acres and above) (1.40 ha and above).

Resources	Activities						Total
	Coconut	Arecanut + pepper	Cocoa	Banana	Tapioca	Cow	
1	2	3	4	5	6	7	8
1. Land (acre)	1	1	1	1	1	0	-
2. Labour (man hours)							
a) June to Sept.	105 (9.6)	153 (13.9)	34 (3.1)	613 (55.8)	102 (9.3)	91 (8.3)	1098 (100.0)
b) Oct. to Dec.	75 (11.0)	173 (25.3)	49 (7.2)	232 (33.9)	87 (12.7)	68 (9.9)	684 (100.0)
c) Jan. to May	76 (5.6)	229 (16.7)	59 (4.3)	667 (48.7)	224 (16.4)	114 (8.3)	1369 (100.0)
3. Irrigation (hours)	48 (9.5)	150 (29.8)	43 (8.6)	232 (46.1)	30 (6.0)	0	503 (100.0)
4. Capital (rupees)	2188 (12.0)	2654 (14.5)	501 (2.7)	9364 (51.3)	1364 (7.5)	2190 (12.0)	18261 (100.0)

(Figures in parenthesis show percentage to tot 1)

The next most resource intensive activity was arecanut plus pepper with percentage utilization lying between 10 and 34 per cent. For all the categories, cocoa was the least labour and capital intensive activity. With respect to irrigation, smallest input coefficient over all categories was for tapioca. Based on the intensity of capital used, the activities arranged in the descending order will be banana, arecanut plus pepper, cow, coconut, tapioca and cocoa. The seasonal utilization of labour exhibited certain patterns with respect to individual crops and these patterns were the same in all categories of holdings. For coconut, maximum utilization was during the first season, followed by second and third seasons. For banana and tapioca, maximum utilization was during the third season followed invariably by first and then second seasons. For arecanut plus pepper, maximum utilization was during third season, followed by first and second seasons for the first and second categories of holdings. In the case of third and fourth categories, labour utilization during second season exceeded that during first season. This must have occured due to extension of some operations of the first season to second season on the larger farms. The nature and utilization of labour for cow activity was uniform through out the year, and therefore, this input was appertioned on the basis of duration of season.

2. Resource restriction levels

The programming as stated in the methodology, was done for model farms, one each from each category of holdings. The size and resources used on each of these model farms were determined and are given in Table 4.5. In setting up programming matrices, these resource levels obtained were posted as the levels of restriction of these resources for the respective category of holdings.

3. Net margins

In the first equation

$Z = CX$

in the linear programming model, vector C is the net margins of the activities included in the model. Net margin is the net returns per unit of an activity or it may be considered as returns to fixed resources. Thus, if in the solution for the model where Z is maximized, level of ith activity is X_i, then addition to Z from this activity would be C_iX_i where C_i is the net margin of the ith activity. For perennial crop activities, average annual net present worths were used as net margins. In the case of arecanut plus pepper, average annual net present worths were determined separately and then added to get the net margins for the combined enterprise. The costs and returns flows and their present worths for coconut, arecanut, pepper and cocoa under categories I to IV are given in appendices II, III, IV and V respectively.

Net present worths of the perennial crop activities under the four categories of holdings are given in Table 4.6. It can be seen from the table that net present worths for all crops, in general, showed an increasing trend from the first to the fourth category. For coconut, net present worth increased from Rs.26,832 in the first category to Rs.37,744 in the fourth category - an increase of about 41 per cent. In the case of arecanut plus pepper, the net present worth increased by 48 per cent from Rs.32,164 in the first category to Rs.47,513 in the fourth category. The highest increase in the net present worth was observed in the case of cocoa. From Rs.5,080 in the first category, net present worth of cocoa increased by 96 per cent to Rs.9,955 in the fourth category, indicating the better scope for cocoa cultivation in larger holdings. It can thus be inferred that in general, farms in the upper categories are successively more efficient than farms in the lower categories with respect to individual perennial crop activities.

For comparison between crops, however, net present worth is not a reliable measure because of the difference in the economic life period of crops. For such comparison, as also between annuals and perennials, average annual net present worths were used. These average annual net present worths, along with net margins for banana, tapioca and cow activities are presented in Table 4.7. A diagramatic presentation of net margins is given in Fig.1.

Table 4.5 Availability of resources on model farms in the four categories of holdings.

Resources	Categories			
1	I 2	II 3	III 4	IV 5
1. Land (acres)	0.89	1.10	2.14	3.64
2. Labour (man hours)				
a) June to Sept.	274	323	307	708
b) Oct. to Dec.	168	184	197	446
c) Jan. to May	274	334	438	727
3. Irrigation (hours)	75	105	218	254
4. Capital (rupees)	5008	5073	6991	15817

Table 4.6 Net present worth of perennial crops under four categories of holdings (rupees per acre).

Activities	Categories			
1	I 2	II 3	III 4	IV 6
Coconut	26832	33181	34801	37744
Arecanut + Pepper	32164	45300	45747	47513
Cocoa	5080	7943	9955	9955

As is evident from Table 4.7, banana is the activity which has the highest net margin in all categories of holdings. Among the four categories for banana, category III had the highest net margin of Rs.8,275. For tapioca, the net margin of Rs.1,436 in the first and second categories increased by 15 per cent to Rs.1,652 in the third and fourth categories. Net margin for cow activity was worked out for the sample as a whole without reference to categories. Therefore, a uniform net margin of Rs.1,974 was obtained for all categories of holdings.

The net margins for perennial crop activities like their net present worths, showed an increasing trend from first to the fourth category. In all categories of holdings, the ranking of activities with respect to the size of net margin was about the same, with banana having the highest net margin followed by arecanut plus pepper, coconut, cow, tapioca and cocoa.

These results, however, have to be interpreted keeping in view of the resource requirements or input coefficients of the activities. Banana and arecanut plus pepper which have first and second highest net margins respectively, also had largest input coefficients for all resources in the same order. Showing the same relationship between net margin and resource intensity, cocoa which was the least labour and capital intensive of all activities, also had the smallest

Table 4.7 Net margins for activities under the four categories of holdings (rupees per acre/ per head of cow)

Activities 1	Categories I 2	II 3	III 4	IV 5
Coconut	2494	3084	3235	3509
Arecanut + Pepper	3294	4652	4718	4882
Cocoa	557	870	1091	1091
Banana	8266	7502	8275	7522
Tapioca	1436	1436	1652	1652
Cow	1974	1974	1974	1974

net margin in all categories of holdings. Thus, it can be infered that, if all resources are available in unlimitted quantities, the profit maximizing option would be specialization in banana. Other activities in decreasing order of profitability are arecanut plus pepper, coconut, cow, tapioca and cocoa. The question of determining the most profitable combination of activities would arise only when some resources are scarce and limiting.

4. Solutions to programming matrices

For each of the four categories of holdings, matrices were developed by combining information relevent to each given in Tables 4.1 to 4.5 and Table 4.7. These matrices were solved with the aid of computer. A comparative study of the results with the existing situations is presented categorywise below.

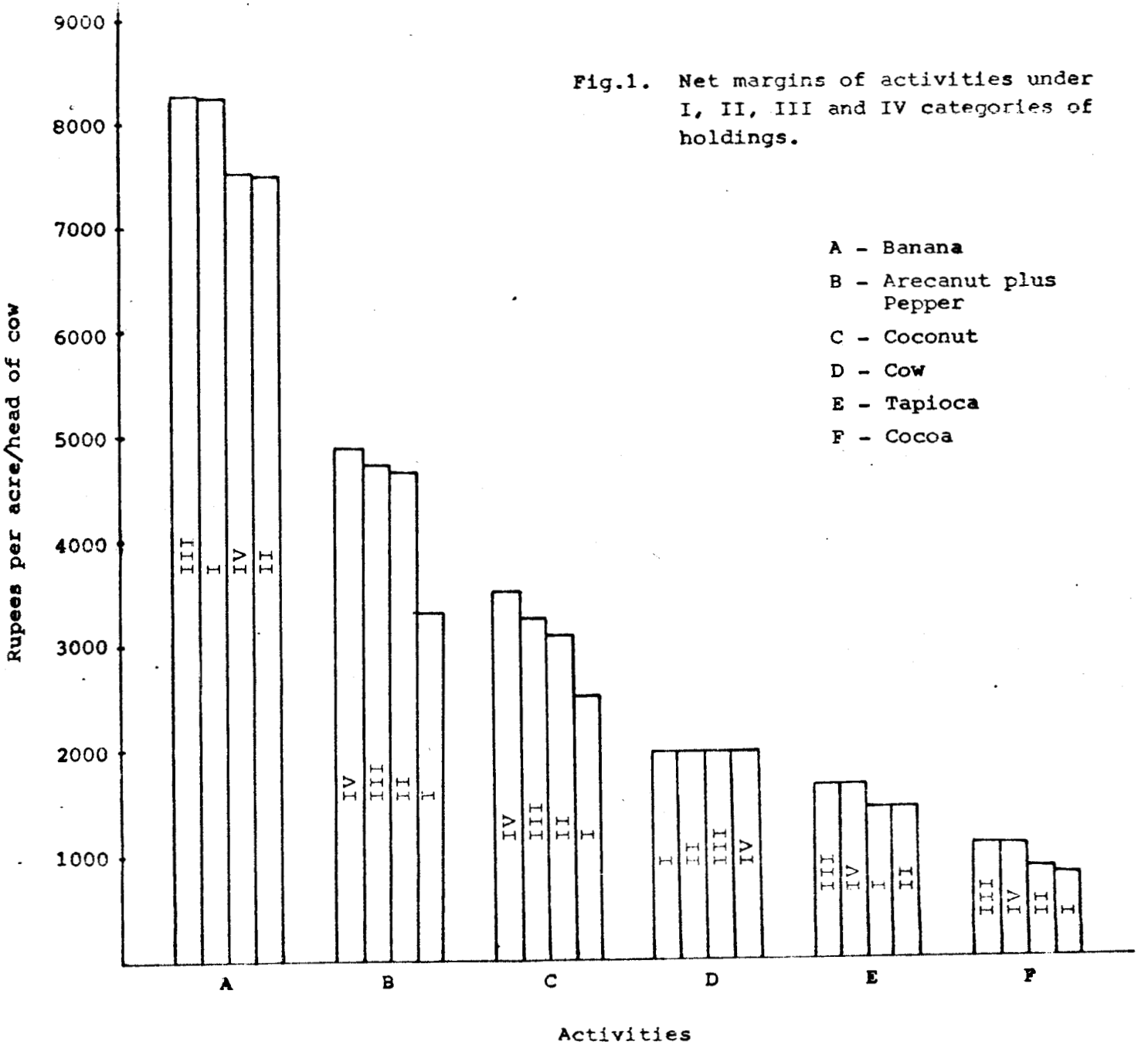

Fig.1. Net margins of activities under I, II, III and IV categories of holdings.

4.1 Category I. The existing and optimal plans for the model farm of category I are compared in Table 4.8.

It can be seen from Table 4.8 that in the optimal plan area under coconut and banana increased by 60 per cent and 120 per cent respectively while arecanut was eliminated. The optimum yielding plant population on the model farm for category I consisted of 48 coconut palms and 220 banana plants. The number of cows in the optimal plan appeared as 0.69 which may be taken as one - the nearest whole number - since cow activity can realistically be taken up only with atleast one cow. But the fraction itself has importance in its implications. It indicates that, to maintain optimality, such a cow activity cannot utilize more than 69 per cent of existing input coefficients for labour and capital. It also implies that the net income from such an activity would be 69 per cent of the net margin used for the cow activity in the programming. Alternatively, since the average milk yield per head of cow included in the programming was 1214.7 liters per annum, the optimal milk production would be 69 per cent of this, or about 838 liters for which only resources could be made available. The net income on the model farm for category I increased from Rs.3,198.00 under the existing plan by 52 per cent, to Rs.4,854.02 under the optimal plan.

4.2 Category II. Table 4.9 gives the comparative figures

Table 4.8 Existing and optimal farm plans for Category I.

Items	Existing plan		Optimal plan		
	Number of yielding plants/ head of cow	Area (acre)	Area (acre)	Number of yielding plants/ head of cow	Percentage change over existing plan
1	2	3	4	5	6
Coconut	30	0.42	0.67	48	59.52
Arecanut	200	0.37	-	-	-
Banana	100	0.10	0.22	220	120.00
Cow	1	-	-	0.69	-
Net income (₹)	3198.00		4854.02		51.78

Table 4.9 Existing and optimal farm plans for Category II.

Items	Existing plan		Optimal plan		
	Number of yielding plants/ head of cow	Area (acre)	Area (acre)	Number of yielding plants/ head of cow	Percentage change over existing plan
1	2	3	4	5	6
Coconut	30	0.42	0.56	40	33.33
Arecanut	250	0.48	-	-	-
Arecanut + Pepper	-	-	0.50	274	-
Banana	200	0.20	0.04	40	-80.00
Cow	1	-	-	0.81	-
Net income (₹)	5400.00		5939.10		9.98

under existing and optimal farm plans for second category of holdings. The reallocation under optimal plan for category II resulted in a decrease in area under banana by 80 per cent. Area under coconut increased by 33 per cent. While arecanut as a single enterprise occupied an area of 0.45 acres on the existing plan, the combined arecanut plus pepper activity occupied an area of exactly half an acre in the optimal plan. In terms of plant population, the optimal plan had 40 yielding coconut palms, 274 arecanut palms together with pepper vines trained on them and 40 banana plants. The number of cows in the optimal plan appeared as 0.81 which may be approximated as one. In terms of optimal milk production, this implied 984 liters of milk per annum. The net income of Rs.5,400.00 under the existing plan increased by 10 per cent in the optimal plan to Rs.5,939.10.

4.3 Category III. Existing and optimal plans for the model farm of category III are compared in Table 4.10. Optimal plan for this category showed a clear tendency towards specialization in coconut. Area under coconut increased by 264 per cent with the number of yielding coconut palms going up from 40 in the existing plan to 145 in the optimal plan. This increase was made possible by elimination of arec nut, and a reduction in area under banana by 67 per cent. Cow activity at the level of 0.35 in the optimal plan, indicates optimal production of 425 liters of milk per annum. The

Table 4.10 Existing and optimal farm plans for Category III.

Items	Existing plan		Optimal plan		
	Number of yielding plants/ head of cow	Area (acre)	Area (acre)	Number of yielding plants/ head of cow	Percentage change over existing plan
1	2	3	4	5	6
Coconut	40	0.56	2.04	145	264.28
Arecanut	700	1.28	-	-	-
Banana	300	0.30	0.10	100	-66.66
Cow	1	-	-	0.35	-
Net income (Rs)	7363.00		8100.27		10.01

optimal enterprise combination resulted in a 10 per cent increase in net income from Rs.7,363 in the existing plan to Rs.8,100.27 in the optimal plan.

4.4 Category IV. In the optimal plan for category IV, given in Table 4.11, area under coconut increased by 55 per cent. This was made possible through release of 0.73 acre which was under arecanut in the existing plan, and a reduction by eight per cent in the area under banana. In terms of plant population, optimal plan had 155 coconut palms and 460 banana plants. There was also scope for marginal increase in milk production by about 230 liters from 3430 liters under the existing plan. The net income of Rs.14,160.00 in the existing plan, increased by nine per cent, to Rs.15,418.87 in the optimal plan.

Table 4.11 Existing and optimal farm plans for Category IV.

Items	Existing plan		Optimal plan		
	Number of yielding plants/ head of cow	Area (acre)	Area (acre)	Number of yielding plants/ head of cow	Percentage change over existing plan
1	2	3	4	5	6
Coconut	100	1.41	2.18	155	54.61
Arecanut	400	0.73	-	-	-
Banana	500	0.50	0.46	460	-8.00
Cows	2	-	-	2.19	-
Net income (Rs)	14160.00		15418.87		8.89

4.5 Conclusions. Observing changes in the optimal plans over the existing plans for all the categories of holdings, some general trends can be discerned. Area under coconut increased in the optimal plans for all the categories. In the optimal plans for third and fourth categories, coconut dominated to the extent of occupying 95 per cent and 83 per cent of the available land respectively. Thus optimal plans give a clear indication that under the existing conditions, it would be more profitable to bring more area under coconut in all categories of holdings. Banana occured in all the optimal plans, but showed some increase in area only in the first category, while area declined in the optimal plans of other categories. Thus although banana is the most profitable

activity solely with reference to net margins, its higher requirement of resources per unit area coupled with restrictions in the availability of these resources under the existing conditions make it necessary to limit the level of this activity especially on the larger sized holdings. Arecanut plus pepper activity appeared only in the optimal plan for the second category. The level of cow activity in terms of milk production declined in all but the last category. Cocoa and tapioca, because of their low net margins, did not appear in any of the optimal plans. Maximum increase in net income of 52 per cent occured in the optimal plan for the first category of holdings, that is on the smallest farms. It is interesting to note that it was only in the optimal plan for this category that rice under bandha, the activity with the highest net margin, registered an increase over the area in the existing plan. In their study on suburban farms in Punjab, Dhawan and Johl (1967) had also recorded a maximum percentage increase in net returns of about 103 per cent in optimal plans for small farms. In the other categories, increase in net income was about the same at around 10 per cent. It is thus clear that there exists possibility of increasing incomes on all categories of farms through optimal allocation of resources under the existing conditions, especially on the smallest farms.

5. Resource utilization in optimal plans

For crop activities, land is the resource into which other resources are added directly or indirectly to effect production. Land was the only resource which was fully utilized in all the optimal plans and thus acted as a common constraint in all categories of holdings. The percentage utilization of available resources on the optimal plans for the four categories of holding are given in Table 4.12, and the pattern of utilization is discussed categorywise below.

5.1 Category I. Limiting constraints besides land are labour in the third season and capital. Available labour was used up to the extent of 97 per cent in the first season and 89 per cent in the second season. This indicates excess, unutilized labour to the extent of three and eleven per cent in first and second seasons. Irrigation was almost fully used up with only a slight excess of about one per cent of available amount remaining unused.

5.2 Category II. Capital, irrigation and second season labour were fully utilised in the optimal plan besides land. However, available labour during the first and third seasons were used only to the extent of 83 per cent and 32 per cent respectively.

5.3 Category III. About 14 per cent or available capital amounting to Rs.955.95 remained unutilized in the optimal plan

Table 4.12 Percentage utilization of available resources in the optimal plans.

Resources 1	Categories I 2	II 3	III 4	IV 5
1. Land	100.00	100.00	100.00	100.00
2. Labour				
a) June to Sept.	97.15	83.39	100.00	100.00
b) Oct. to Dec.	88.88	100.00	100.00	100.00
c) Jan. to May	100.00	82.08	54.49	95.06
3. Irrigation	98.61	100.00	50.71	82.87
4. Capital	100.00	100.00	86.33	87.52

for this category. Available labour was fully utilized in first and second seasons. But labour in the third season was used up only to the extent of 55 per cent. Similarly only 51 per cent of the available irrigation was utilized in the optimal plan indicating an excess of 49 per cent of available amount.

5.4 Category IV. The pattern of resource utilization was similar to that in the third category, but the degree of excess was much less. The percentage of utilization of labour in the third season and irrigation were 95 per cent and 83 per cent respectively. As in the third category capital was not fully utilized and about 13 per cent of available amount remained as excess.

5.5 Conclusions. An examination of the pattern of resource utilization in the optimal plans for the various categories of holdings provides some important conclusions. It can be seen that the optimal plans have resulted in more efficient use of the limiting resources. In all the four categories of holdings some of the resources that were fully utilised under the existing plans have remained in excess under the optimal plans indicating more efficient resource use. Similarly it can be seen that labour utilization, in general, was highly imbalanced among the three seasons under the existing plans. While labour was utilised fully under optimal plans in certain seasons, in other season or seasons it remained in surplus. Previously, Johl and Khalon (1966) had reported serious imbalances in agricultural labour supply and its use in their study on synthetic farm situation in the Pakhawal block of Ludhiana district, Punjab. Similarly, in a study aimed at formulating optimal farm plans in different agro-climatic zones of Himachal Pradesh, Nadd et al. (1978) detected existence of surplus labour in the hilly areas of the state. The authors suggested promotion of agro-based industries in the area to absorb the excess labour force. In the present case, optimal utilization of each resource expressed as percentage to the amount of the resource used on the model farms under the existing plans, given in Table 4.12, brings out clearly the imbalances in resource utilization under the existing plans. For instance, in the

second category, while second season labour was fully utilized, surplus labour to the extent of 17 per cent and 18 per cent of available amounts appeared respectively in the first and third seasons. The imbalance is more glaring in category III where labour was surplus to the extent of 46 per cent of available amount in the third season, whereas full utilization was observed in the first and second seasons. Further, irrigation and capital also remained unutilized to the extent of 49 per cent and 14 per cent respectively. It is clear that if first and second season labour constraints can be relaxed, it would be possible to make use of these excess resources profitably. In category IV, the pattern is exactly the same, but the extent of surplus of third season labour and irrigation is much less. Capital, however, remained unutilized to about the same extent at 12 per cent of available amount. Availability of significant amounts of excess capital in the third and fourth categories indicates the possibility for exploring the feasibility of utilising the excess amounts for taking up some supplementary enterprise. The excess capital amounting to Rs.956 and Rs.1972 respectively can be used to raise appropriate sized units of backyard poultry which do not require any resource other than capital. On the whole, the resource utilization pattern in the optimal plans points to the need for better management of resources on all the categories of holdings for maximizing resource use efficiency.

6. Impact of price changes

Rigidity of optimal plans discussed above depends almost completely on the stability of the prices of outputs from various activities. Changes in input coefficients and changes in the availability and prices of resources could also alter the plans. However, given the existing situation, these factors are likely to remain more constant than output prices. Changes in relative prices of different outputs would lead to alterations in net margins and in the allocation of available land and other resources among the different activities to maintain optimality. Because perennial crop activities are involved, changes in optimal plans due to variations in prices of outputs can only be taken as indications as to the directions in which scarce resources should flow to maintain optimality, rather than to any abrupt change in the crop mix. For the latter kind of changes to practically occur, relative prices will have to change on a permanent, long term basis.

In this study, the effects of price changes were studied by considering 25 per cent increase in the prices per kilogram of dry pepper and unprocessed tapioca. Increase in the price of pepper would also result in an increase in the net margin of the arecanut plus pepper enterprise. The calculation of net present worths for pepper under the four categories of holdings at revised price is given in

appendix VI. The net margins for arecanut plus pepper and tapioca at the revised prices are given in Table 4.13.

The net margins for tapioca and arecanut plus pepper in the previous programming matrices were substituted by these revised net margins, and the matrices were solved. The resulting optimal enterprise combinations for the four categories of holdings termed optimal plan II, are discussed in comparison with existing plans and optimal plans at the original prices (herein after refered to as optimal plan I) below.

6.1 Category I. As can be seen from Table 4.14, tapioca has entered optimal plan II for the first category with an area of 0.17 acre, while it was not present either in the existing plan or optimal plan I. Area under coconut and banana declined over optimal plan I by nine and fifty per cent respectively. Number of cows at 1.09 indicates a milk production of 1324 liters which is an increase of 56 per cent over optimal plan I. As in the optimal plan I, arecanut alone as an activity was eliminated since it was not included in the programming. Net income in optimal plan II increased by 54 per cent over the existing plan, as against the increase of about 52 per cent by optimal plan I over existing plan.

6.2 Category II. Under optimal plan II given in Table 4.15, area under coconut declined slightly by five per cent over

Table 4.13 Net margins for arecanut plus pepper and tapioca at revised prices under the four categories of holdings (rupees/acre).

Activities 1	Categories I 2	II 3	III 4	IV 5
Arecanut + Pepper	4228	5742	5749	5913
Tapioca	2174	2174	2479	2479

Table 4.14 Optimal plan II for first category of holdings.

Activities 1	Area(acre)/ head of cow 2	Percentage change over existing plan 3	Percentage change over optimal plan I 4
Coconut	0.61	45.24	-8.95
Banana	0.11	10.00	-50.00
Tapioca	0.17	-	-
Cow	1.09	-	57.97
Net income (Rs)	4929.77	54.15	1.56

Table 4.15 Optimal plan II for second category of holdings

Activities 1	Area(acre)/ head of cow 2	Percentage change over existing plan 3	Percentage change over optimal plan I 4
Coconut	0.53	26.19	-5.36
Arecanut + Pepper	0.57	-	14.00
Banana	0.00	-100.00	-100.00
Cow	0.80	-	-1.23
Net income (Rs)	6500.32	20.38	9.45

the optimal plan I while banana was eliminated. However, area under arecanut plus pepper increased by 14 per cent over optimal plan I. Level of cow activity remained practically unchanged indicating optimal milk production of 972 liters per annum. Net income increased by 20 per cent over the existing plan while in optimal plan I, the increase was only by 10 per cent over existing plan.

6.3 Category III. Area under coconut in the optimal plan II for the third category declined by 14 per cent over optimal plan I. Arecanut plus pepper which did not occur in optimal plan I, appeared in optimal plan II with an area of 0.23 acres. Area under banana increased by 60 per cent over

optimal plan I. Cow activity which had entered at a very low level of 0.35 in optimal plan I, was eliminated from optimal plan II. Net income increased by 13 per cent over the existing plan as against an increase of 10 per cent by optimal plan I over existing plan.

6.4 Category IV. In optimal plan II for the fourth category of holdings, it can be seen from Table 4.17 that area under coconut declined by 10 per cent over optimal plan I. Arecanut plus pepper which was not present in optimal plan I, appeared here with an area of 0.37 acre. Area under banana increased by seven per cent over optimal plan I. The number of cows at 1.74 indicates a production of about 2114 liters of milk per annum, which is a decrease of 21 per cent over milk production in optimal plan I. While net income increased by about 10 per cent over the existing plan, the increase over net income in optimal plan I was negligible, at 0.01 per cent. Thus, although enterprise mix has changed, net income has remained practically the same.

6.5 Resource utilization. Percentage utilization of available resources in optimal plan II for different categories of holdings are given in Table 4.18. It can be seen from the table that besides land, second season labour was also fully utilized on all categories of holdings. First season labour remained in excess to the extent of eight per cent and twenty per cent in optimal plan II for the first and second

Table 4.16 Optimal plan II for third category of holdings.

Activities 1	Area(acre)/ head of cow 2	Percentage change over existing plan 3	Percentage change over optimal plan I 4
Coconut	1.75	212.50	-14.22
Arecanut + Pepper	0.23	-	-
Banana	0.16	-46.65	60.50
Cow	0.00	-100.00	-100.00
Net income (Rs)	8306.22	12.81	2.54

Table 4.17 Optimal plan II for fourth category of holdings.

Activities 1	Area(acre)/ head of cow 2	Percentage change over existing plan 3	Percentage change over optimal plan I 4
Coconut	1.79	26.95	-17.89
Arecanut + Pepper	0.37	-	-
Banana	0.49	-2.00	6.52
Cow	1.74	-	-20.54
Net income (Rs)	15541.08	9.75	0.01

Table 4.18 Percentage utilization of available resources in optimal plan II.

Resources 1	Categories I 2	II 3	III 4	IV 5
1. Land	100.00	100.00	100.00	100.00
2. Labour				
a) June to Sept.	91.72	80.12	100.00	99.99
b) Oct. to Dec.	100.00	100.00	100.00	100.00
c) Jan. to May	100.00	78.45	65.99	100.00
3. Irrigation	69.95	100.00	67.72	100.00
4. Capital	100.00	96.49	82.18	83.88

Categories respectively. Third season labour was utilized only to the extent of 79 and 66 per cent on second and third categories. While irrigation remained in excess in first and third categories, capital remained in excess to the extent of four per cent, 18 per cent and 16 per cent on optimal plan II for second, third and fourth categories.

The pattern of resource utilization under the optimal plan II also brings out clearly the imbalances in resource use under the existing plans. There is scope for cutting down expenditure on irrigation in categories I and III. Imbalance in labour use among the three season are evident on categories I, II and III, while in the fourth category available labour has been fully used up in all the three

seasons. Significant amounts of capital are available as surplus on third and fourth categories indicating scope for undertaking supplementary enterprise as under optimal plan I.

6.6 Conclusion. By observing changes in optimal plan II over the optimal plan I for all the categories of holdings, certain trends can be noticed which are the direct result of change in unit prices of pepper and tapioca. Area under coconut declined in optimal plan II over optimal plan I for all categories of holdings. Arecanut plus pepper entered the optimal plan II for the second third and fourth categories, while in optimal plan I, it had occured only in the second category. In the case of banana, area declined in optimal plan II for the first category by 50 per cent, while it was eliminated in optimal plan II for the second category. In the third and fourth categories however, area under banana increased in optimal plan II over optimal plan I by sixty and seven per cent respectively. Due to increase in its price, tapioca entered optimal plan II for the first category while it was not present in optimal plan I for any of the four categories of holdings. This observation is significant, since an increase of even 25 per cent in unit price of tapioca did not result in it being feasible for cultivation in relatively larger holdings. Level of cow activity increased in optimal plan II over optimal plan I only in the first category. While in optimal plan II for the second category

it remained at about the same level, it was eliminated in optimal plan II for the third category. In the fourth category level of cow activity declined in optimal plan II by 21 per cent over optimal plan I. It could be surmised that under the prevailing conditions and even with minor changes in the crop prices, milk production becomes an inseparable part of very small land holders.

It is clear that moderate changes in the prices of some outputs, by altering the relative net margins and profitability structure of activities, can cause variations in optimal resource allocation under existing conditions. In the case of annual crops, this can serve as clear indications as to the direction in which enterprise combination need to be altered to maintain optimality. By careful management of resource use and enterprise mix with the help of such indications, product price cycles with duration longer than the life period of annual crops can be profitably weathered. For combinations involving perennial crops, however, abrupt changes in the enterprise mix, even if considerable gains in net income in the short run are indicated, are clearly not practical. Instead, short run changes in the relative price structure of perennial crops, often lead to changes in the allocation of variable resources like fertilizers. From a purely biological point of view, this may not be desirable. Thus, frequent short run fluctuations in the prices of outputs of perennial crops, can cause

considerable difficulty to the farmer in the optimal management of resources. This points to the need for evolving suitable price polices aimed at maintaining a regime of stable relative prices in the short run, with a long term perspective for the principal perennial crops, that enter the crop mix on garden lands in the state. In the long run, changes in the relative price structure including those of inputs can at the same time, act as indications to the modifications to be made in the enterprise mix for optimising resource use and maximizing farm income.

Summary

SUMMARY

This study on optimal enterprise combinations on the garden land farms in Kerala was carried out using data collected from sample holdings selected from Pananchery panchayat under Ollukkara development block in Trichur district. A simple random sample of 72 holdings from the ninth ward of the panchayat and possessing a minimum of 0.50 acre (0.20 hectare) of garden land was analysed. This sample was grouped, according to size of garden land holdings, into four categories.

The existing enterprise mix and resource use on the sample holdings were studied. The existing activities on sample holdings included cultivation of coconut, arecanut, pepper, cocoa, banana and tapioca and rearing of milch cows. The six major constraints identified were land, labour availability during three seasons viz. June to September, October to December and January to May, irrigation and working capital. The intensity of utilization of these resources under the four categories of holdings under existing conditions, were studied by calculating amounts of resources used per acre/per head of cow. The resource use pattern indicated that banana was the most resource intensive activity in all categories of holdings followed by arecanut plus pepper. Cocoa was the least capital and labour intensive activity in all categories of holdings.

Net margins or returns to fixed resources per unit of activity (acre/head of cow) were worked out for all activities, separately under each category of holdings. For perennial crops, average annual net present worths were taken as the net margins. Net margins for arecanut and pepper were determined separately and added up to get the net margin for the combined arecanut plus pepper activity. For calculation of net present worth, the costs and returns flow over the economic life period of each crop was determined using cross sectional data from the study and in consultation with technical experts on concerned crop. The pattern of net present worths for each crop under the four categories of holdings indicated that net present worths increased with increase in the size of holding. Maximum increase in net present worth from the first to the fourth category of holdings was recorded in the case of cocoa with an increase of nearly 96 per cent. For coconut and arecanut plus pepper the increase in net present worth from first to fourth category worked out to 41 per cent and 48 per cent respectively. Average annual net present worths worked out by dividing annuity factor for the economic life period of the crops into their net present worths for respective categories of holdings indicated a similar pattern. Comparison of net margins for all the activities revealed that benana was the activity with highest net margin in all categories of holdings. Arecanut plus pepper activity came second followed by coconut, cow and tapioca in that order. Cocoa had the smallest net margins in

all categories of holdings.

Optimal plans were worked out for model farms selected from each category of holdings. For this linear programming matrices were set up for each category using data on input coefficients, available resource levels and net margins for activities under the particular category. The matrices were solved and the resulting optimal enterprise mix for each category of holdings were studied in comparison with existing plans.

Optimal plan for category I showed an increase in area under coconut and banana by 60 per cent and 120 per cent respectively. This increase in area was facilitated by elimination of arecanut from the plan and the consequent release of 0.37 acre of land which was under arecanut in the existing plan. The level of cow activity declined in terms of milk production by 31 per cent in the optimal plan. Net income increased by 52 per cent from Rs.3,198.00 in existing plan to Rs.4,854.00 in the optimal plan.

Optimal plan for category II showed an increase in area under coconut by 33 per cent. Arecanut plus pepper entered the plan at the level of 0.50 acre. Area under banana declined by 80 per cent from 0.20 acre under existing plan to 0.04 acre under optimal plan. Level of cow activity at 0.81 indicated an optimum milk production of 184 liters per annum. Net income for this category increased under optimal

plan by 10 per cent over the existing plan.

Optimal plan for category III indicated a clear tendency toward specialization in coconut with a drastic increase under its area by 264 per cent. This increase resulted from the release of 1.28 acres under arecanut and 0.20 acre under banana. Level cow activity also markedly declined to 0.35 indicating optimal production of 425 liters of milk per annum. Optimal plan registered an increase of 10 per cent in the net income over existing plan.

Area under coconut increased by 55 per cent in the optimal plan for the fourth category of holdings. Area under banana declined by eight per cent. Elimination of arecanut released 0.73 acres which contributed towards increase in area under coconut. Cow activity, in terms of milk production, increased with additional production of 230 liters of milk per annum. Net income under optimal plan showed an increase of just under nine per cent over the existing plan.

Thus optimal plans for all categories of holdings indicated increase in area under coconut. Area under banana declined in all except the first category of holdings. Similarly, level of cow activity also declined in all except the last category of holding. Except the optimal plan for second category which included 0.50 acre of arecanut plus pepper, all other optimal plans had three enterprises viz. coconut, banana

and cow. Cocoa and tapioca did not appear in any of the optimal plans. Maximum increase in net income of 52 per cent was recorded in the optimal plan for the first category of holdings.

The results of the study indicated that under existing conditions farm resources were not utilized optimally in any category of holdings. Imbalance in utilization of labour during the three seasons was also noticed. Optimal plans resulted in more efficient use of resources. Optimal plans under existing conditions indicated existence of surplus labour in all categories of holdings. Irrigation and capital were also found to be not fully utilized on farms in the third and fourth categories. Existence of excess capital indicated the need for promoting supplementary enterprise like back yard poultry.

The sensitivity of the optimal plans were tested by considering 25 per cent increase in the prices of pepper and tapioca. The optimal plans under the revised prices (OPII) showed decline in area under coconut over optimal plans at the original prices (OPI) in all categories of holdings. Simultaneously, tapioca entered OPII for the first category, and arecanut plus pepper entered OPII for the second, third and fourth categories. Area under banana in OPII declined by 50 per cent over the area in OPI for the first category. Banana was eliminated from OPII for second category. However in OPII for third and fourth categories

area under banana increased over OFI by sixty per cent and seven per cent respectively. Level of cow activity increased in OPII over OFI only in the first category; by about 58 per cent. While it remained at about the same level in the second category, it was eliminated from OPII for the third category. In the fourth category it declined by 21 per cent over the level in OFI. Maximum gain in net income in OPII over net income in existing plan was recorded in the first category with an increase of slightly over 54 per cent. The increases were 20 per cent, 13 per cent and 10 per cent respectively in OPII for second, third and fourth categories of holdings. The study of resource utilization patterns in OPII also indicated the necessity for better management of resources on the farms in all categories of holdings in the study area.

References

REFERENCES

Arora, U.P.S., and Prasad, B. (1972) Impact of optimal production patterns on farm incomes and borrowings. Indian J. Agric. Econ., 27(4) : 172.

Balasubramanian, S.V. (1975) Study on resource use efficiency in garden land agriculture in Dindigual division, Madurai district - A normative approach. Unpublished M.Sc.(Ag.) thesis submitted to Tamil Nadu Agricultural University, Coimbatore.

Calkins, P.H. (1981) Nutritional adaptations of linear programming for planning rural development. American J. Agric. Econ., 63(2) : 247 - 254.

*Chakrabarti, M.C. (1956) Linear programming. Asian Econ. Rev., 1(4) : 367 - 373.

Chauhan, K.K.S., Verma, R.C., and Shukla, G.C. (1974) Impact of commercial crops on farm incomes and resource use in Jaipur district of Rajasthan. Indian J. Agric. Econ., 29(3) : 106 - 114.

Day, H.R. and Sparling, E. (1977) Optimization models in agricultural and resource economics in A Survey of Agricultural Economics Literature, Vol, 2. Ed. Martin, L.R. pp. 93 - 94.

Desai, D.K. (1963) Economics of cropping pattern of Gujarat State. Indian J. Agric. Econ., 18(1) : 106 - 114.

Desai, D.K. (1960) Linear programming applied to problems in Indian agriculture. Indian J. Agric. Econ., 15(2) : 59 - 65.

Dhawan, K.C., and Johl, S.S. (1967) Comparative profitability of dairy enterprise in relation to crop cultivation on suburban farms in Punjab. Indian J. Agric. Econ., 22(1) : 23 - 34.

Dhawan, K.C. and Johl, S.S. (1969) An economic analysis of dairy enterprise vis-a-vis crop cultivation in Punjab (A case study). Indian J. Agric. Econ., 24(2) : 53 - 72.

Dhawan, K.C., and Kahlon, A.S. (1974) Impact of yield increasing food grain technology on the cultivation of commercial crops. Indian J. Agric. Econ., 29(3) : 92 - 105.

Dhondyal, S.P. (1960) Farm planning approach to agricultural production. Indian J. Agric. Econ., 15(5) : 42 - 45.

George, K.V., and Joseph, P.T. (1973) Cost-benefit analysis of investment in tree crops. Indian J. Agric. Econ., 28(4) : 172 - 180.

Guglani, P.L., and Sirohi, A.S. (1972) Production patterns in the union territory of Delhi - a case study. Indian J. Agric. Econ., 27(4) : 137 - 157.

Heady, E.O. (1954) Simplified presentation and logical aspects of linear programming techniques. J. Fm. Econ., 36(5) : 1035 - 1048.

*Hildreth, C., and Reiter, S. (1951) On the choice of a crop rotation plan in Activity Analysis of Production and Allocation. Ed. Koopmans, T.C. Cowles Commission Monograph 13, New York : Wiley. pp. 177 - 188.

Johl, S.S., and Kahlon, A.S. (1963) Economics of cropping pattern (An analytical case study). Indian J. Agric. Econ., 18(1) : 132 - 142.

Johl, S.S., and Kahlon, A.S. (1966) Labour utilization patterns and employment potentials of Punjab farms (A case study). Indian J. Agric. Econ., 21(1) : 77-83.

Johl, S.S., and Kapur, T.R. (1973) Fundamentals of Farm Business Management. Kalyani Publishers, New Delhi. p. 212.

Kahlon, A.S., and Johl, S.S. (1962a) Applications of budgeting and linear programming in farm management analysis. Indian J. Agric. Econ., 17(1) : 225 - 232.

Kahlon, A.S., and Johl, S.S. (1962b) Application of linear programming to rotational planning. Indian J. Agric. Econ., 17(4) : 45 - 48.

King, R.A. (1953) Some applications of activity analysis in agricultural economics. J. Fm. Econ., 35(5) : 823 - 834.

Malya, M. (1962) Linear programming and farm planning. Indian J. Agric. Econ., 17(1) : 200 - 211.

McCarl, B.A. (1977) Experiences with farmer oriented linear programming for crop planning. Canadian J. Agric. Econ., 25(1) : 17 - 30.

McCrokle, Jr., C.L. (1955) Linear programming as a tool in farm management analysis. J. Fm. Econ., 37(5) : 1222 - 1235.

Muthyunjaya, and Sirohi, A.S. (1979) Enterprise system for stability and growth on draught-prone farms. An application of parametric linear programming. Indian J. Agric. Econ., 34(1) : 27 - 42.

uthusamy, . (1982) Study on optimization of resource use in gardenland farms of Namakkal block in Salem district. Unpublished M.Sc.(Ag.) thesis submitted to the Tamil Nadu Agricultural University, Coimbatore.

Nadda, A.L., Sharma, A.L., Bhadauria, U.S., and Swarup, R. (1978) Optimising crop production patterns in different agroclimatic zones of Himachal Pradesh. Indian J. Agric. Econ., 33(4) : 22 - 28.

Norton, G.W., Easter, R.W., and Roe, T.L. (1980) American Indian farm planning. An analytical approach to tribal decision making. American J. Agric. Econ., 62(4) : 689 - 699.

Onyenwaku, C.E., Ogunfowora, O., and Falusi, A.O. (1982) An inter-regional programming model for agricultural planning in Nigeria. Indian J. Agric. Econ., 37(4) : 483 - 493.

Pandey, R.N., and Chogal, T.S. (1980) Prospects of increasing income and employment on mixed farms. Indian J. Agric. Econ., 35(4) : 144 - 151.

Patel, R.K., and Gangwar, A.C. (1983) Estimation of potential for farm income and employment in dry farming areas of Haryana. Agric. Situ. India, 38(3) : 135 - 139.

Peterson, G.A. (1955) Selection of maximum profit combinations of livestock enterprises and crop rotations. J. Fm. Econ., 37(3) : 546 - 554.

Randhawa, N.S., and Heady, E.O. (1966) Spatial programming of production for agricultural development in India. Indian J. Agric. Econ., 21(3) : 14 - 22.

Sadasivan, G., and Rai, S.C. (1967) A plan for allocation of cultivable land among the different economic crops of Kerala state. Jrl. of the Ind. Soc. of Ag. Stat., 19(1) : 92 - 107.

Sahni, O.P., and Johl, S.S. (1967) Economic potentials of vegetable cultivation on sullage water farms in Punjab (a case study). Indian J. Agric. Econ., 22(3) : 75 - 82.

Sankhayan, P.L., and Sidhu, D.S. (1974) Regional specialization in the cultivation of commercial crops vis-a-vis regional self-sufficiency in food grain production - A case of Punjab. Indian J. Agric. Econ. 29(3) : 115 - 123.

Shanmugam, K. (1979) An approach to planning for integrated rural development in Annur block, Coimbatore district. Unpublished M.Sc.(Ag.) thesis submitted to the Tamil Nadu Agricultural University, Coimbatore.

Sharma, A.C., and Kahlon, A.S. (1972) Impact of technological development on the normative shifts in cropping patterns. Indian J. Agric. Econ., 27(4) : 158 - 165.

Singh, I.J. (1971) The transformation of traditional agriculture: A case study of Punjab, India. American J. Agric. Econ., 53(2) : 278 - 284.

Singh, I., and Sirohi, A.S. (1976) Optimization of water resource of upper Ganga canal in western Utter Pradesh. Indian J. Agric. Econ., 31(1) : 92 - 107.

Singh, K. (1977) Some alternative strategies for optimal use of land and other resources in the hill region of Utter Pradesh. Indian J. Agric. Econ., 32(3) : 113 - 120.

Singh, R.D., Verma, K.K., and Singh, L.R. (1972) Production possibilities and resource use pattern on small farms. A comparative study in three regions of Utter Pradesh. Indian J. Agric. Econ., 27(4) : 126 - 136.

Singh, R.V., Patel, R.K., and Ahlwat, S.S. (1977) Impact of integrated crop and milk production on small farms in Punjab. Indian J. Agric. Econ., 32(3) : 136 - 143.

Sirohi, A.S., and Gangwar, A.C. (1968) Economic optima in resource allocation for the cultivators of Kanjhawala block. Indian J. Agric. Econ., 23(3) : 1 - 13.

Sirohi, A.S., and Sharma, B.M. (1978) Maximization of returns through farms planning under fertilizer constraint in Aliput block of the union territory of Delhi. Indian J. Agric. Econ., 33(2) : 47 - 56.

Sirohi, A.S., Sharma, B.M., Singh, I., and Dayal, R. (1980) Role of dairy and poultry enterprises for increasing income and employment on farms in the Union Territory of Delhi. Indian J. Agric. Econ., 35(4) : 112 - 119.

Sivaprakasan, K.S. (1974) Determination of optimal plans for resource use and income efficiency in farms of Pattukkottai division, Thanjavur district. Unpublished M.Sc.(Ag.) thesis submitted to Tamil Nadu Agricultural University, Coimbatore.

Stewart, F.J., Hall, H.H., and Smith, E.D. (1979) Potential for increased income in small farms in Appalachian Kentucky. American J. Agric. Econ., 61(1) : 77 - 82.

Swanson, E.R., and Fox, K. (1954) The selection of livestock enterprise by activity analysis. J. Fm. Econ., 36(1) : 78 - 86.

Swanson, E.R. (1961) Programmed solutions to practical farm problems. J. Fm. Econ., 43(2) : 386 - 392.

Thamodaran, R., Bhide, S., and Heady, E.O. (1982) An Economic analysis of water management systems in southern Tamil Nadu - Production function and programming approach. Indian J. Agric. Econ., 37(1) : 43 - 55.

Yang, W.Y. (1965) Methods of Farm Management Investigation. Food and Agricultural Organization, Rome. p. 102.

* Originals not seen

Appendices

APPENDICES

Appendix I

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF HORTICULTURE
VELLANIKKARA

Department of Agricultural Economics
Schedule for farm survey

1. Name of farmer and address

2. Family particulars

Sl. No. 1	Names of members 2	Sex 3	Age 4	Occupation/ activity 5	Remarks 6

3. Land use

No. of plot/ fragment 1	Land area operated				Type of tenancy			Remarks 9
	Wet 2	Garden 3	Dry 4	Total 5	Own 6	Leased in 7	Leased out 8	

4. Crop layout

Plot No.	Crops (area under/No. of trees)			No./ area irrigated	Source & mode of irrigation	Remarks (mixed or specialised)
	Name	Adult/ bearing	Young/non bearing			
1	2	3	4	5	6	7

5. Livestock inventory

Sl. No.	Species	Description and sex	No.	Breed	Age	Present value	Remarks
1	2	3	4	5	6	7	8

6. Livestock maintenance expenditure (total for a year)

Items	Period	Milk animals				Dry				Remarks
		Item	Price/ unit	Quantity	Value	Item	Price/ unit	Quantity	Value	
1	2	3	4	5	6	7	8	9	10	11
Roughages	Early									
	Late									
Concentrates	Early									
	Late									
Veterinary and other charges										

Items	Period	Milk animals				Dry				Remarks
		Item	Price/ unit	Quantity	Value	Item	Price/ unit	Quantity	Value	
1	2	3	4	5	6	7	8	9	10	11
Labour (family/ hired) (hours per day)										
Milking										
Cleaning animals										
Cleaning stalls										
Feeding										
Other misc. charges										

7. Input use and costs. Name of crop _____ No. of trees/area

Period	Manuring and fertilizer application					Inter culture	
	Item	Price/ unit	Quantity FP/P	Labour Hired M/W	Labour Family M/W	Hired M/W	Family M/W
1	2	3	4	5	6	7	8
June - September							
October - December							
January - May							

Period	Irrigation			Plant protection				
	No./ week	Labour		Item	Price/ unit	Quantity	Labour	
		Hired	Family				Hired	Family
1	2	M/W 3	M/W 4	5	6	7	M/W 8	M/W 9
June - September								
October - December								
January - May								

Period	Miscellaneous				Harvesting		Remarks
	Price/ unit	Quantity	Labour		Labour		
			Hired	Family	Hired	Family	
1	2	3	M/W 4	M/W 5	M/W 6	M/W 7	8
June - September							
October - December							
January - May							

8. Output and returns

Period	Production			Price/ unit	Total value	Remarks
	Total production	Quantity for home use	Quantity sold			
1	2	3	4	5	6	7
June - September						
October - December						
January - May						

9. Income from livestock

Name of produce	Period	Production	Quantity for home use	Quantity sold	Price/ unit	Total value	Remarks
1	2	3	4	5	6	7	8

(FP - Farm produced, P - Purchased, M - Men, W - Women)

Appendix II (i) Flow of costs and returns and present worth of costs and returns for coconut - Category I.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2677	0.917	2455	1 to 7	0	-	-
2	1403	0.842	1181	8	3847	0.502	1931
3	1403	0.772	1083	9	3847	0.460	1770
4	1403	0.708	993	10	5770	0.422	2435
5	1403	0.650	912	11	5770	0.388	2239
6	1403	0.596	836	12	7693	0.356	2739
7	1403	0.547	767	13	7693	0.326	2508
8 to 40	2648	5.725	15160	14	7693	0.299	2300
				15 to 40	11540	2.972	34297
Total of present worths			23387	-	-	-	50219

Appendix II (ii) Flow of costs and returns and present worth of costs and returns for coconut - Category II.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2505	0.917	2297	1 to 7	0	-	-
2	1231	0.842	1037	8	4118	0.502	2067
3	1231	0.772	950	9	4118	0.460	1894
4	1231	0.708	872	10	6177	0.422	2607
5	1231	0.650	800	11	6177	0.388	2397
6	1231	0.596	734	12	8235	0.356	2932
7	1231	0.547	673	13	8235	0.326	2685
8 to 40	2308	5.725	13213	14	8235	0.299	2462
				15 to 40	12353	2.972	36713
Total of present worths			20576	-	-	-	53757

Appendix II (iii) Flow of costs and returns and present worth of costs and returns for coconut - Category III.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2502	0.917	2294	1 to 7	0	-	-
2	1228	0.842	1034	8	4240	0.502	2129
3	1228	0.772	948	9	4240	0.460	1950
4	1228	0.708	869	10	6360	0.422	2684
5	1228	0.650	798	11	6360	0.388	2468
6	1228	0.596	732	12	8479	0.356	3019
7	1228	0.547	672	13	8479	0.326	2764
8 to 40	2306	5.725	13202	14	8479	0.299	2535
				15 to 40	12719	2.972	37801
Total of present worths	20549	-	-	-	-	-	55350

Appendix II (iv) Flow of costs and returns and present worth of costs and returns for coconut - Category IV.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2536	0.917	2326	1 to 7	0	-	-
2	1262	0.842	1063	8	4500	0.502	2259
3	1262	0.772	974	9	4500	0.460	2070
4	1262	0.708	894	10	6751	0.422	2849
5	1262	0.650	820	11	6751	0.388	2619
6	1262	0.596	752	12	9001	0.356	3204
7	1262	0.547	690	13	9001	0.326	2934
8 to 40	2356	5.725	13488	14	9001	0.299	2609
				15 to 40	13501	2.972	40125
Total of present worths	21007	-	-	-	-	-	58751

Appendix III (i) Flow of costs and returns, and present worth of costs and returns for arecanut - Category I.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	3649	0.917	3346	1 to 7	0	-	-
2	1579	0.842	1330	8	3061	0.502	1537
3	1579	0.772	1219	9	3061	0.460	1408
4	1579	0.708	1118	10	4591	0.422	1937
5	1579	0.650	1026	11	4591	0.388	1781
6	1579	0.596	941	12	6121	0.356	2179
7	1579	0.547	864	13	6121	0.326	1995
8 to 40	2842	5.725	16271	14	6121	0.299	1830
				15 to 40	9182	2.972	27289
Total of present worths			26115	-	-	-	39956

Appendix III (ii) Flows of costs and returns, and present worth of costs and returns for arecanut - Category II.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	3367	0.917	3088	1 to 7	0	-	-
2	1297	0.842	1092	8	3085	0.502	1549
3	1297	0.772	1001	9	3085	0.460	1419
4	1297	0.708	918	10	4628	0.422	1953
5	1297	0.650	843	11	4628	0.388	1796
6	1297	0.596	773	12	6171	0.356	2197
7	1297	0.547	710	13	6171	0.326	2012
8 to 40	2293	5.725	13127	14	6171	0.299	1845
				15 to 40	9256	2.972	27509
Total of present worths			21552	-	-	-	40280

Appendix III (iii) Flows of costs and returns and present worth of costs and returns for arecanut - Category III.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	3054	0.917	2801	1 to 7	0	-	-
2	984	0.842	829	8	2605	0.502	1308
3	984	0.772	760	9	2605	0.460	1198
4	984	0.708	697	10	3908	0.422	1649
5	984	0.650	640	11	3908	0.388	1516
6	984	0.596	587	12	5211	0.356	1855
7	984	0.547	538	13	5211	0.326	1699
8 to 40	1662	5.725	9515	14	5211	0.299	1558
				15 to 40	7816	2.972	23229
Total of present worths			16367	-	-	-	34012

Appendix III (iv) Flows of costs and returns and present worth of costs and returns for arecanut - Category IV.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	3231	0.917	2963	1 to 7	0	-	-
2	1161	0.842	978	8	2966	0.502	1489
3	1161	0.772	896	9	2966	0.460	1364
4	1161	0.708	822	10	4449	0.422	1878
5	1161	0.650	755	11	4449	0.388	1726
6	1161	0.596	692	12	5932	0.356	2112
7	1161	0.547	635	13	5932	0.326	1934
8 to 40	2021	5.725	11570	14	5932	0.299	1774
				15 to 40	8898	2.972	26445
Total of present worths			19311	-	-	-	38722

Appendix IV (i) Flow of costs and returns and present worth of costs and returns for pepper - Category I.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2065	0.917	1894	1 to 3	0	-	-
2	1130	0.842	952	4	2029	0.708	1437
3	1130	0.772	872	5	3043	0.650	1978
4 to 20	2046	5.889	12049	6	4057	0.596	2418
				7 to 20	6086	4.643	28257
Total of present worths			15767	-	-	-	34090

Appendix IV (ii) Flow of costs and returns and present worth of costs and returns for pepper - Category II.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1884	0.917	1728	1 to 3	0	-	-
2	949	0.842	799	4	2370	0.708	1678
3	949	0.772	733	5	3555	0.650	2311
4 to 20	1697	5.889	9994	6	4740	0.596	2825
				7 to 20	7110	4.643	33012
Total of present worths			13254	-	-	-	39826

Appendix IV (iii) **Flow of costs and returns and present worth of costs and returns of pepper - Category III and IV.**

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1626	0.917	1491	1 to 3	0	0 -	-
2	691	0.842	582	4	2233	0.708	1581
3	691	0.772	534	5	3350	0.650	2178
4 to 20	1158	5.889	6820	6	4467	0.596	2662
				7 to 20	6700	4.643	31108
Total of present worths			9427	-	-	-	37529

Appendix V (i) **Flow of costs and returns and present worth of costs and return for Cocoa - Category I.**

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1124	0.917	1031	1 to 3	0	-	-
2	514	0.842	433	4	739	0.708	523
3	514	0.772	397	5	1108	0.650	720
4 to 20	929	5.889	5471	6	1477	0.596	880
				7 to 20	2216	4.643	10289
Total of present worths			7332	-	-	-	12412

Appendix V (ii) **Flow of costs and returns and present worth of costs and return for Cocoa - Category II.**

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year	Returns (Rs/acre) 5	Discount factor at 9% 6	Present worth of returns 7
1	1057	0.917	969	1 to 3	0	-	-
2	447	0.842	376	4	828	0.708	586
3	447	0.772	345	5	1242	0.650	807
4 to 20	726	5.889	4275	6	1655	0.596	986
				7 to 20	2483	4.643	11529
Total of present worths			5965	-	-	-	13908

Appendix V (iii) **Flow of costs and returns and present worth of costs and return for Cocoa - Category III and IV**

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1011	0.917	927	1 to 3	0	-	-
2	401	0.842	338	4	915	0.708	648
3	401	0.772	310	5	1372	0.650	892
4 to 20	652	5.889	3840	6	1829	0.596	1090
				7 to 20	2744	4.643	12740
Total of present worths			5415	-	-	-	15370

Appendix VI (i) Flow of costs and returns and present worths of costs and returns for pepper - Category I.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	2065	0.917	1894	1 to 3	0	-	-
2	1130	0.842	952	4	2536	0.708	1795
3	1130	0.772	872	5	3804	0.650	2473
4 to 20	2046	5.869	12049	6	5072	0.596	3023
				7 to 20	7608	4.643	35324
Total of present worths			15767	-	-	-	42615

Appendix VI (ii) Flow of costs and returns and present worths of costs and returns for pepper - Category II.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1884	0.917	1728	1 to 3	0	-	-
2	949	0.842	799	4	2962	0.709	2097
3	949	0.772	733	5	4444	0.650	2888
4 to 20	1697	5.889	9994	6	5925	0.596	3531
				7 to 20	8887	4.643	41262
Total of present worths			13254	-	-	-	49778

Appendix VI (iii) Flow of costs and returns and present worths of costs and returns for Pepper - Category III and IV.

Year 1	Costs (Rs/acre) 2	Discount factor at 9% 3	Present worth of costs 4	Year 5	Returns (Rs/acre) 6	Discount factor at 9% 7	Present worth of returns 8
1	1626	0.917	1491	1 to 3	0	-	-
2	691	0.842	582	4	2793	0.708	1977
3	691	0.772	534	5	4190	0.650	2724
4 to 20	1155	5.869	6820	6	5587	0.596	330
				7 to 20	8380	4.643	38908
Total of present worths			9427	-	-	-	46939

OPTIMIZATION OF ENTERPRISE COMBINATIONS WITH SPECIAL REFERENCE TO GARDEN LAND AGRICULTURE

BY

JAYACHANDRAN. N. V.

ABSTRACT OF THESIS

Submitted in partial fulfilment of the

requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Agricultural Economics

COLLEGE OF HORTICULTURE

Vellanikkara - Trichur

1985

ABSTRACT

This study on optimal enterprise combinations on garden land farms in Kerala was carried out using data collected from sample holdings selected from the ninth ward of Panancherry panchayat under Ollukkara block in Trichur district, through simple random sampling. The 72 holdings that formed the sample were grouped into four categories based on size of garden land holdings.

The major constraints identified were land, labour in three seasons viz. June to September, October to December and January to May, irrigation and capital. Banana was identified as the most resource intensive activity followed by arecanut plus pepper. Cocoa was the least labour and capital intensive activity. Net margins calculated per unit of activity indicated that banana had highest net margin in all categories followed by arecanut plus pepper, coconut, cow, tapioca and cocoa in the decreasing order.

Optimal plans worked out under existing conditions using linear programming technique for model farms under the four categories of holdings indicated a uniform tendency of increase in area under coconut over the existing plan. Except the optimal plan for the second category, which included arecanut plus pepper also, all other optimal plans had three enterprises viz. coconut, banana and cow. Cocoa and tapioca did not appear in any optimal plan. Maximum increase in net

income of 52 per cent was recorded in optimal plan for first category. In other categories the increases were ten per cent in both second and third and nine per cent in the fourth category. Optimal plans resulted in more efficient use of resources.

Sensitivity of optimal plans were tested by considering 25 per cent increases in prices of pepper and tapioca. The optimal plans at revised prices indicated decline in area under coconut over optimal plans at original prices in all categories simultaneously followed by appearance of tapioca in the first category and arecanut plus pepper in second, third and fourth categories. Banana was eliminated from second category and cow activity from the third category. Increase in net incomes on revised optimal plans over existing plans worked out to 54 per cent, 20 per cent, 13 per cent and 10 per cent respectively on categories I, II, III and IV.