INTEGRATION OF COFFEE WITH FOOD PRODUCTION: A CASE OF PRODUCERS' COOPERATIVES IN MANNA WEREDA[1]

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ABSTRACT. Induced by national development objectives, cooperatives in coffee growing areas are subject to conflicting activities. On the one hand, they are urged to expand coffee production, and on the other, food shortage and inadequate external supply force them to give priority to food self-sufficiency of the members. In view of this situation, an urgent need is felt to provide the newly emerging coffee growing cooperatives with economic planning procedures. Towards this end, this paper attempts to develop a suitable model for establishing and analyzing optimal plans for different types of cooperatives. The results indicate that the existing production pattern is sub-optimal and need adjustments in order to yield higher incomes and to achieve food self-sufficiency. Optimal cropping plans differ from one type of cooperative to another. In general, the study sheds light on the importance of efficient resource utilization with the complement of improved technology to overcome the problem of self-sufficiency as well as low cash incomes.

1. BACKGROUND

Obviously agriculture plays an important role in the economy of Ethiopia. The objectives of agricultural development in the country comprises assurance of staple food supplies for the rapidly growing population and promotion of foreign exchange earnings for accelerated growth of the overall economy. Basically, in a country like Ethiopia where resource supplies and productivities are limited, these are two competitive objectives of the sector

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which require special consideration in depth both at the macro- and micro-planning levels.

Over the past decade, although backward technology and underutilization of resources inhibited development of the sector,the state has endeavoured to raise agricultural production by transforming the traditional agriculture with the main emphasis on establishing state farms and producers' cooperatives. In particular, besides their role in transforming the peasant agriculture, producers' cooperatives are established with the objective of increasing agricultural production by making use of advanced technology and organized labour. In 1985/86 there were 2323 producers' cooperatives with a cultivated land of nearly 300.000 hectares. According to the ten-years development plan the cooperative sub-sector is expected to dominate the peasant agriculture by the middle of the next decade.

Although there is lack of a satisfactory theory on peasant economy, authors like Schultz [10] and Hopper [6] agree that the peasant farmers use their resources efficiently within the limits of traditional technology. Others like John Wong [14], however, conclude that the traditional peasants are inefficient in their resource utilization. In principle, producers' cooperatives can be assumed to have a considerable organizational potential to adopt new technologies and to control misallocation of resources. But, since they are newly emerging and lack experience, they still need outside support for adequate planning in order to mitigate and eventually overcome the prevailing sub-optimal resource utilization.

Induced by the national development objectives, producers' cooperatives in coffee growing areas are subject to conflicting activities, mainly because their semi-subsistence nature of production established strong traditional links between sales and home use of the total production. This has resulted in growing a mixture of annual food and a perennial cash crop, coffee. Today, on the one hand, the cooperatives are urged to expand coffee production for export, and on the other, food shortage and insecurity of interregional food supply prohibit them from specializing in coffee production. Rather the condition incites them to meet food selfsufficiency levels of their members. In fact, disintegration of food crops and coffee production in the coffee growing areas at this moment cannot be recommended as it would endanger food supply for the specialized cash crop producers.

In view of this situation, an urgent need is felt to provide the coffee growing cooperatives with economic planning procedures enabling them to determine their optimal product mix under a given set of objectives and constraints. This study, in particular attempts to develop a suitable model for establishing and analyzing optimal plans for different types of coffee growing cooperatives. Due emphasis is given to the integration concept and the models are designed to capture all possible interactions between annual crops and coffee.

In this regard the central objective of this study has been to analyze the existing pattern of production and to develop a suitable model for examining the effect of food self-sufficiency constraints on the production pattern and farm income level of coffee growing producers' cooperatives.

2. RESEARCH DESIGN AND METHODOLOGY

The study was conducted in Manna Wereda Keffa administrative region, where coffee grows fairly widely both under traditional and modern cultural practices. The wereda is selected for the study because (1) it is known for its potential in coffee production, (2) most of the cooperatives in the area are established on a large area of coffee common holdings, and (3) Manna is known as one of the food deficit areas which imports much of its food from other weredas. These factors made Manna a typical area to conduct a research on integration of coffee with food production with special reference to cooperatives.

Out of the 21 cooperatives in the Wereda 13 were systematically selected using some judgemental criteria. One year primary data were obtained from the farm records of the cooperatives on land use, labour use, production, consumption, sales, prices, costs, credit etc. Missing data were collected from relevant government organizations to bridge the information gap.

The analytical tools used in the study include:

a) past performance analysis, basically a farm income analysis,
b) whole farm budgeting,
c) investment analysis in coffee production, and
d) Linear Programming (LP) analysis.

Linear programming is widely recognized as one of the methods which deals with the problem of allocating resources among competing activities in the best optimal way. Many economists such as Heady [5], Casey [1], Upton [12] and Rae [9] substantiate the economic importance of linear programming technique in the optimum allocation of limited factors of production among many alternative enterprises. The method has thus gained rapid acceptance in the field of farm planning techniques. Therefore, linear programming is used to derive optimum farm plans for three types of cooperatives to increase the productivity of existing resources and consequently to raise farm income.

The coffee growing cooperatives have specific differences in resource use and capacities, production efficiency and other features. Therefore, representative or typical farms were selected as a basis of linear programming modelling. The representative farm approach involves classifying the universe of farms into a smaller number of homogeneous groups, and constructing a model for a representative farm from each group (Hazell and Norton, [4]). However, the major problem centers on the criteria to be used in farm classifiction. According to Sheehy and McAlexander [11] farms with different limiting factors should not be grouped together, since it will lead to an overestimation of supply possibilities. In this study, land-labour ratio, output-input ratio and relative importance of coffee production were the major criteria used to classify the sample into three different types of cooperatives.

TABLE 1

Classification of Cooperative Farms

Type of Cooperative	Land-labour ratio (ha)	Gross margin per hectare	Percentage of coffee area
Type 1	0.5 - 0.7	985 - 1283	63 - 72
Type 2	1.1 - 1.2	152 - 499	16 - 27
Type 3	0.8 - 1.0	152 - 499	32 - 60

These criteria helped in classifying the cooperatives according to the most limiting factor (i.e. homogeneous restriction criteria). Cooperatives with similar limiting factors are grouped together and hence average results can be reliably generalized for the group. In each group the capacities of the representative farm are derived as the arithmetic mean of the farms included. The averages were used to construct the right hand side values (capacities) of the basic linear programming models for the typical farms.

The linear programming model used in the study maximizes cash income from various crop activities within a production period subject to various constraints.

i.e. Maximize, $Z = C X$

Subject to, $A X (\leq, \geq) B$

$X \geq 0$

Where, Z = Total cash income

C = A vector of the objective function coefficients

X = A vector of activities

A = A vector of input - output coefficients

B = A vector of constraint levels

In the model coffee had to be integrated into the single period static LP model. The objective function coefficient was determined by estimating an average annual margin using discounting technique; the resource requirements (especially labour) were considered at the stage of full production. The capital requirement was assessed for the investment year only.

The Objective Function

The cash income was measured by deducting the variable expenses for inputs and campaign labour, and the subsistence requirements from the gross income.

Activities

The activities considered are categorised into production, harvesting, selling, consumption, campaign labour and transfer activities. In total 37 activities were chosen.

Input-Output Coefficients

The input coefficients for all crop activities, except coffee, were calculated on the basis of the actual requirements of different resources used for those crop activities. However, for coffee, the coefficients were derived from an investment analysis prepared for this purpose.

Constraints

The farm resources considered consist of land, labour, ox-power and working capital, the capacities of which were derived as the arithmetic mean calculated for the respective group. Additional constraints reflect red cherry quota and food subsistence requirements. Furthermore, constraints of crop rotations and yield balancing constraints with harvesting, selling and consumption were introduced. In total 39 constraints were considered in the model. Some of the constraints that need to be explaind in more detail are:

Land: Four categories of land were considered, i.e. cultivable land, coffee land, roots and vegetable land and pasture land. Coffee land was further subdivided into old, stumped and young coffee land, according to the established plantations.

Human labour: The cooperative members and their families were considered as the only available full-time labour force. Ceilings were imposed on the amount of additional campaign labour according to past experience. In line with the cooperatives' by laws no hired labour use was allowed in the model. Four major labour periods were distinguished, i.e. January-March, April-June, July-September, and October-December. Period four was further sub-divided into October-November and November-December labour periods as some of the work to be performed in these months cannot be postpond.

Ox-power: Ox-pair days availability was estimated by taking February-July ploughing season and the number of working days used for production purposes. But for the purpose of separating the peak land preparation priod a February-April ox-power capacity was introduced additionally.

Working capital: The available working capital was calculated to be the difference of the net farm income and the members remuneration in kind. The main interest here is to push the cooperatives to invest most of their cash on productive activities. In addition working capital is supplied by two types of credits which were restricted according to the lending rules for producers' cooperatives.

Subsistence: Four subsistence consumption constraints for cereals, pulses, oil crops and vegetables and root crops were calculated according to relevant standards in order to meet food supply priorities of the cooperatives.

Red cherry quota: This is a supply quota imposed on the cooperatives by service cooperatives which run processing stations.

3. RESULTS AND DISCUSSION

3.1 Existing and budgeted situation

a) Land use pattern: The existing land use pattern of the sample cooperatives is quite diversified and complex, involving several food crops and cash crop, coffee, which compete among themselves for land and other resources. On average out of the total cultivated land about 65 percent is held by annual crops while the remaining 35 percent is used for coffee production (Table 2).

TABLE 2

Cultivated Land and Land-labour Ratios in the Cocperatives

Name of Coopera-tive	Annual Crops (ha.)	Coffee (ha.)	Total cultivated land (ha.)	Land-labour[1] ratio
Siaha	71.0	21.0	92.0	1.2
Feche Lelissa	75.3	27.2	102.5	1.2
Kiftana	57.8	18.9	76.7	1.1
Tassano	42.3	31.0	73.3	1.8
Timuga Dale	47.0	14.5	61.5	0.7
Keway	12.5	32.5	45.0	0.7
Harro	16.6	25.2	41.8	0.8
Sombo Cheka	52.5	24.3	76.8	1.0
Wollo Sefer	42.1	28.0	70.1	1.0
Bosoka	13.5	25.0	38.5	0.5
Afeta	12.8	22.0	34.8	0.6
Geruke Jimate	71.6	14.0	85.6	1.1
Timuga Nole	48.2	13.8	62.0	0.9
Average	43.3	22.9	66.2	0.9

[1]Cultivated area (ha.) per member.

Regarding food crops, maize, sorghum and teff are the most widespread of the commonly grown food crops in all cooperatives. Among these crops, maize and sorghum are the most important basic staples grown for subsistence. A look at the land-labour ratio of each cooperative showed relatively a wide degree of variability ranging from 0.5 to 1.8 hectares of cultivated area per member. These ranges have no significant dissimilarity to that of the individual holdings in the wereda.

b) Labour use: Characteristically the labour force of the coffee growing cooperatives is made up of the cooperative members, their families and some external labour force in the form of campaign labour. On annual basis, a member worked about 187 eight hour days. The average man-days per hectare were found to be 203 days. The highest input of man-days was recorded in the months of November and December. In these months, campaign labourers were needed to participate in temporary, casual work, mainly in coffee picking and cereal harvesting.

c) Ox-power use: None of the sample cooperatives used tractors or other improved tillers. They use draught animals with the traditional model plough to prepare and cultivate their lands. The average arable land per pair of oxen stood at 2.1 hectares ranging from 0.9 to 3.1 hectares. This relationship, by and large, seems adequate to plough the available arable lands.

d) Overall economic performance: Based on actual incomes and expenditures coffee fetches 137 percent higher gross margin per hectare than annual crops (Table 3); i.e. coffee appears to be a remunerative enterprise. The average net farm income after covering variable, and overhead and fixed costs stood at Birr 351 per hectare of cultivated area and at Birr 279 per member, an amount which is certainly insufficient to meet the income requirements of the members and to ensure the equity growth needed for investment.

In unfavourable agricultural years the cooperatives will not cover their operating costs. The highest net farm income per hectare is achieved in those cooperatives which are near to specialize in coffee production.

TABLE 3

Existing Farm Incomes of the Cooperatives

Name of Coopera-tive	Annual Crops GM/ha.	Coffee GM/ha.	Net Farm Income (NFI) NFI /ha	NFI/member
Siaha	383	410	322	360
Feche Lelissa	279	309	251	289
Kiftana	219	1437	419	350
Tassano	206	215	131	212
Timuga Dale	193	620	158	101
Keway	273	1793	1180	652
Harro	250	100	58	34
Sombo Cheka	378	609	342	346
Wollo Sefer	323	563	210	171
Bosoka	617	1518	970	362
Afeta	625	1294	865	445
Geruke Jimate	383	615	305	293
Timuga Nole	355	175	229	175
Average	743	313	351	279

e) **Existing returns vs budgeted returns:** The objective of budgeting was to assess the impact on cooperative returns if they would apply all technologies available to them without changing their production patterns. Compared with the existing gross margins the improved technology would result in an increase by 95 percent for annual crops and by 29 percent for coffee. These improvements were of course sustainable only if the cooperatives are able to use external labour (i.e. campaign labour) in addition to the full time labour force available for timely operations during the peak harvesting months of October, November and December. They demonstrate a considerable gap in the cooperatives' technical efficiency.

3.2 Investment Analysis in Coffee Production

An investment analysis for both newly planted and stumped coffee was applied in order to develop technical coefficients which are needed to integrate the perennial activities with annual food crops in a short-term static planning model. For both activities optimum stumping cycles had to be determined as a prerequisite to set up cash flow budgets over the economic life cycle of the tree.

Economists have adopted various techniques to determine the replacement cycle of perennial crops and other durable inputs. In all methods the principle involved in replacement decision-making process follows the criterion of maximizing revenue over time (i.e., maximizing average net revenue over time). Faris [3], Winder and Trant [13], Childs [2] and Olsen (8) applied a method that accounts for the concept of the time value of money and maximizes the average annualized net revenue. In their empirical analysis, they compared expected annual net revenue for a current perennial crop (durable input) to the equivalent annuity from a replacement plantation. The optimum replacement time is reached in the year where expected net revenue for the current plantation is less than the (maximum) equivalent annuity from the replacement plantation. The equivalent annuity in a specific period of time can be derived in the following mathematical form:

$$NPV = \sum_{t=1}^{T} \frac{R - C}{(1 + i)^t}$$

$$AT = NPV \frac{q^T (q - 1)}{q^T - 1}, \quad q = 1 + i$$

Where, NPV = Net present value in year T;
R = Gross returns in each year;
C = Costs in each year;
AT = The equivalent annuity in year T; and,
i = The discount rate.

Applying this basic concept and considering the normally expected yield levels, prices and costs, stumped coffee should be restumped every tenth year while planted coffee should first be stumped after the twelfth year followed by restumping every tenth year. Stumped coffee gives higher revenue in earlier years but yield decline more quickly than in newly planted coffee while newly planted coffee has a higher negative cash balance in earlier years.

Based on the discounted variable costs for an optimal rehabilitation cycle, objective function values of both production activities were calculated as an annuity of the present values. For old coffee no variable costs were assumed. Similarly, the objective function coefficients of the coffee selling activities, the selling prices, were calculated by converting the discounted cash flow of gross returns over the total quantity harvested into its annuity. Expected prices were derived from the prevailing market prices for clean beans and converted into dried and red cherry prices according to the existing market price relations. Yield coefficients were derived from the expected yield stream in the cash flow analysis as an annual average yields. However, yields of old coffee were estimated based on historical information. Initial establishment costs for new and stumped coffee plantations were considered as the requirement for working capital in order not to underestimate actual investment costs.

3.3. Optimal Linear Programming Solutions

a) Land Use Pattern: The optimum solutions envisaged significant changes in the land use pattern (Table 4). In type one (relatively small-size coopertive) the area under annual crops increased from 33 percent in the existing plan to 52 percent in the optimal plan reducing the share of coffee from 67 percent to 48 percent. This cooperative, although it expanded the area of annual crops in the optimal plan, still could meet only 75 percent of its food requirements for self-sufficiency. In contrast, in type two (relatively large-size coopertive), the area under annual crops declined from 76 percent in the existing plan to 55 percent in the optimal plan. A dramatic increase is shown in the hectarage under young (newly planted) and stumped coffee. The total area under coffee increased from 24 to 45 percent. In type three (about average-sited cooperative) both annual crops and coffee production areas remained unchanged compared to the existing plan. A shift is made only among the annual crops and the various types of coffee plantations. Thus in terms of production pattern one can conclude that this type of coopertive operates nearly at an optimal product mix.

TABLE 4

Production Patterns of the Existing and Optimal Plans (ha)

Types of Crops	Type 1		Type 2		Type 3	
	Existing plan	Optimal plan	Existing plan	Optimal plan	Existing plan	Optimal plan
1. Cereals	12.5	13.6	53.9	40.1	34.4	32.3
2. Pulses	0.1	2.0	8.3	3.1	1.9	2.6
3. Oil crops	-	1.8	2.4	2.8	0.2	2.0
4. Roots & Veg.	0.3	3.0	0.5	3.0	0.4	3.0
Annual crops-total	12.9	20.4	65.1	49.0	36.9	39.9
5. Young coffee	8.0	11.0	4.0	23.7	6.2	6.2
6. Stumped coffee	8.0	8.0	4.9	16.5	5.7	14.4
7. Old coffee	10.5	-	11.6	-	10.9	2.2
Coffee land-total	26.5	19.0	20.5	40.2	22.8	22.8
Cultivated Land Total	39.4	39.4	85.6	89.2	59.7	62.7

In all types of cooperatives maize, horse beans, niger seed and roots and vegetables are optimal cropping options among the annual crops while crops like sorghum, teff, barley and others did not appear in the optimal plans. In all plans maize was the dominating food crop.

TABLE 5

MVPs of Resources Used in the Optimal Plans

Constraints	Type 1	Type 2	Type 3
Cultivated land	1167	739	623
Stumped Coffee land	-127	164	16
Old Coffe land	-	164	16
Roots and Veg. land	404	831	947
October labour	1.50	1.50	1.50
November labour	1.50	1.50	1.50
Own capital	-	0.74	2.17
Credit	-	0.68	2.11

b) Resource use: As indicated by the rather high marginal values (shadow prices in Table 5), land is a scarce resource in all types of cooperatives, but its scarcity is much more marked in type one than in the other types. The labour utilization level of all types of cooperatives during peak months of harvesting was the most restrictive productive resource which determined the type and level of activities that appear in the optimal plans. In all types of coopertives, in October and November the members and family labour force were fully used. In these months intensive red cherry and other crop harvesting operations required the use of external labour force. For this reason, in October an additional 62, 55 and 57 campaign labourers were needed for a minimum of ten working days in type one, two and three cooperatives respectively. For November this figure reduced to 30, 36 and 34 campaign labourers. In the remaining months, type two cooperative seemed to be more susceptible to labour shortage than the other types. Shadow prices of labour did not exceed the assumed cost of Birr 1.50 per man-day of campaign labour, as the available campaign labour force was not fully used.

As regards ox-power use in the optimal plans, all types of cooperatives did not fully utilized the available capacity but only 54, 66 and 71 percent of it.

In the optimal plan of type one coopertive working capital was not limiting the cropping activities as it might have been expected. The available cash at hand was adequate to finance all expenses both in coffee and annual crop production. On the contrary, working capital was a major constraint affecting the production patterns and farm income levels of type two and three cooperatives. In type two limitation of own cash and available credits diverted the cropping choice from the production of coffee to annual crops as they are less capital intensive. In type three cooperative, in constrast to the cases above, investment and operating expenses had to be met exclusively by credits, as own funds were almost nil. This prevented the cooperative from expanding the most profitable crops like young coffee and maize production. This serious influence of funds in the optimization problem was reflected in the shadow prices of working capital and credit.

c) **Net farm incomes and subsistence consumption:** Net farm incomes to be expected from the optimum farm plans compare favourably to the poor past performance and show improvements against the budgeted plans in spite of the additional constraints which had to be observed in the model (i.e. red cherry quota, food self-sufficiency, etc.) (Table 6). This holds only partly true for type one cooperative, the actual performance of which even exceeded the budgeted one because of higher than normal returns. The optimal plan of type one cooperative even shows a further decline of the net farm income due to imposition of food self-sufficiency requirements (75 percent of the total consumption). Subsistence requirements take a high (70 percent) share of the net farm income, leaving the cooperative with a very limited amount of cash income (Birr 101 per member). Even optimizing resource allocation cannot overcome the extreme shortage of land in this case.

TABLE 6

Comparison of Net Farm Incomes Among Different Plans

Detail	Type 1			Type 2			Type 3		
	Existing plan	Budgeted plan	Optimal plan	Existing plan	Budgeted plan	Optimal plan	Existing plan	Budgeted plan	Optimal plan
NFI/member	453	433	338	310	605	863	178	588	625
Subsustence/ member	86	174	238	153	278	315	211	245	285
Cash income/ member	367	259	101	157	327	548	- 32	343	341
Cash income (as % of NFI)	81	60	30	51	54	63	- 18	58	55
NFI/ha of CA	805	769	602	275	536	765	185	609	648

NFI = Net Farm Income
CA = Cultivated Area

Type two cooperatives show a big jump in net farm income both comparing actual and budgeted and comparing budgeted and optimal plans. Realloction of inputs resulted in a considerable advantage and lifted the net farm income to a self-sustaining level of Birr 863 per member 37 percent of which is needed for staple food requirements of the members, the remaining Birr 548 in cash being at disposal for cash remunertion of members and equity growth of the cooperatives (retained profit).

TABLE 7

Cash Income per Member Under
Changed Constraints

	Changes	Type 1	Type 2	Type 3
A.	Basic plan	101	548	341
B.	No red cherry quota	250	678	501
C.	Red cherry quota (50%)	200	671	447
D.	Transfer of pasture land	229[1]	690	364
E.	Transfer of pasture land	91[2]	-	-
F.	Increase in Capital	-	-	406
	Percentage			
	B as % of A	248	124	147
	C as % of A	198	122	131
	D as % of A	227	126	107
	E as % of A	90	-	-
	F as % of A	-	-	119

[1]Transfer activity at 75% self-sufficiency level
[2]Transfer activity at 100% self-sufficiency level

For type three cooperative the severe capital restrictions limit the effect of input reallocation; the optimal plan is slightly better than the budgeted plan (Birr 625 per member). Nevertheless, after meeting subsistence requirements fully, 55 percent of the net farm income (Birr 341) remains for cash to be partly retained for investment purposes and partly to the members.

In general, the cash income of all cooperatives is dependent on sales of coffee. In addition, type two and three cooperatives have some marketable surplus of maize and roots and vegetables which are additional sources of cash incomes.

To test the influence of changes in policy measures and land use pattern on result variations; red cherry quota and transfer of surplus pasture land to crop production were considered (Table 7). In addition, for type three cooperative where working capital was the most binding constraint, the availability of credit was extended.

Reduction of the red cherry supply quota by 50 and 100 percent did not cause any change in the production pattern of all types of cooperatives. But it resulted in an increase of their income generating potential as the demand for external labour was diminished and sales of clean coffee beans were increased.

The possibility to transfer a pasture land into cultivated area allowed type two and three cooperatives to expand their annual crops, mostly maize. In type one cooperative, at 75 percent self-sufficiency level, coffee area was expanded; while an extended 100 percent self-sufficiency requirement forced it to expand the maize area. Net farm income is of course positively influenced, if pasture is transferred to crop land.

Increase of credit limits in type three cooperative resulted in a tremendous change in the cropping mix. It allowed the area of young coffee to be expanded by 150 percent and that of stumped coffee by 15 percent while the maize area was reduced by 29 percent, and old coffee plantations were either stumped or uprooted. Following from this shift in the cropping pattern, the cash income of the cooperative increased by 19 percent over the basic plan.

3.5 Sensitivity Analysis

Analysis of the objective function, right hand side and input-output coefficients is an established means to test the stability of the optimal solution against the repercussion of major changes

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3.5 Sensitivity Analysis

Analysis of the objective function, right hand side and input-output coefficients is an established means to test the stability of the optimal solution against the repercussion of major changes or uncertainties in respect to estimation of the various parameters. Because of their economic importance and relatively uncontrollable nature, the key parameters selected for sensitivity analysis were variations of output prices and yields.

Impact of variations in output prices: The following schemes of price reductions were followed:

Run 1: Prices of annual crops were declined by 15 percent and that of dry cherry and clean coffee beans by 25 percent.

Run 2: Prices of annual crops were declined by 30 percent while the reduction fo dry cherry and clean coffee beans prices remained at 25 percent.

Run 3: All prices of the above crops declined by 50 percent.

Price variations did not induce any change in the optimal output mix of the first type of cooperative, i.e. its production plan is stable in regard to price uncertainty. However, reduction of prices by 50 percent induced a substantial change in the production pattern of type two and three cooperatives in favour of maize and young coffee plantations. In type three cooperative some changes also appeared at an overall reduction of prices by 15 and 25 percent in favour of maize production. In general, the results indicated that reduction of product prices had only limited effect on the production pattern of the cooperatives. Only dramatic price falls of about 50 percent induced a serious decline of old and stumped coffee areas while that of annual crops preferably maize increased to a higher level. These effects are restricted to large cooperatives where working capital is more limited than land.

As expected, a decline of prices resulted in a reduction of the cooperatives' net farm income (Table 8). This reduction is especially serious in the case of the first cooperative. Each of the assumed price reduction prevented the cooperative from covering the cash demand of the members leave alone the ability of increasing equity capital.

TABLE 8

Impact of Price and Yild Variations on
Net Farm Income per Member

Variations	Type 1	Type 2	Type 3
A. Basic plan	338	863	625
B. 15 and 25% price reduction	210	600	436
C. 30 and 25% price reduction	176	523	353
D. 50% price reduction	30	235	135
E. 12% coffee yield reduction	296	777	575
Percentage			
B as % of A	62	70	70
C as % of A	52	61	56
D as % of A	9	27	22
E as % of A	88	90	92

Impact of variations in crop yields: In this part sensitivity analysis is made on the effects of both coffee and food crop yield variations.

In the case of coffee, the LP model was run assuming pessimistic forecasts of young and stumped coffee yields, i.e. a yield reduction by 12 percent each (Table 8). In type one and type two cooperatives this yield reduction did not result in any change in area covered by each activity. It was in type three only where a slight increase of maize area was induced at the expense of old and stumped coffee hectarage. The main effect of lower coffee yield in all types of coopertives was a reduction of clean coffee output which ultimately decreased farm incomes.

or uncertainties in respect to estimation of the various parameters. Because of their economic importance and relatively uncontrollable nature, the key parameters selected for sensitivity analysis were variations of output prices and yields.

Impact of variations in output prices: The following schemes of price reductions were followed:

Run 1: Prices of annual crops were declined by 15 percent and that of dry cherry and clean coffee beans by 25 percent.

Run 2: Prices of annual crops were declined by 30 percent while the reduction fo dry cherry and clean coffee beans prices remained at 25 percent.

Run 3: All prices of the above crops declined by 50 percent.

Price variations did not induce any change in the optimal output mix of the first type of cooperative, i.e. its production plan is stable in regard to price uncertainty. However, reduction of prices by 50 percent induced a substantial change in the production pattern of type two and three cooperatives in favour of maize and young coffee plantations. In type three cooperative some changes also appeared at an overall reduction of prices by 15 and 25 percent in favour of maize production. In general, the results indicated that reduction of product prices had only limited effect on the production pattern of the cooperatives. Only dramatic price falls of about 50 percent induced a serious decline of old and stumped coffee areas while that of annual crops preferably maize increased to a higher level. These effects are restricted to large cooperatives where working capital is more limited than land.

As expected, a decline of prices resulted in a reduction of the cooperatives' net farm income (Table 8). This reduction is especially serious in the case of the first cooperative. Each of the assumed price reduction prevented the cooperative from covering the cash demand of the members leave alone the ability of increasing equity capital.

Regarding annual crops, since the cooperatives under study have near-subsistence nature of production, under conditions of uncertainty they may adopt a production strategy that maximizes a sufficient yield under adverse conditions. Therefore, in this respect the main interest was to identify a strategy that maximizes yield under the most adverse conditions the farmers may consider likely to arise and to see its impact on the subsistence production of the cooperatives. To determine the maximum total yield the concept of Wald Maximin Criterion (a methodology applied by low, [17]) was employed in a game theoretic approach. According to this criterion, the decision maker tries to choose the best of the worst.

TABLE 9

Yield Under Two States of Nature (Q/ha)

State of Nature	Maize	Sorghum	Teff	Barley	Horse beans
S_1	10	15	8	8	8
S_2	15	20	8	6	7

Haricot beans	Field peas	Niger seed	Lin seed	Roots and vegetables
5	8	4	3	25
5	8	4	3	35

Two states of nature with different yield levels were specified (Table 9), and incorporated into the basic LP matrix in a way as to assure sufficient food in the worst state of nature.

Significant changes in the land use pattern resulted from this additional constraints in all types of cooperatives. The first state of nature (S_1), being more adverse in the whole farm planning context than the second one, annual crop production shifted to sorghum, field peas, niger seed and roots and vegetables. The maximum yield level under this state of nature satisfied the minimum subsistence requirement of type two and three coopertives while in type one only parts of the requirements are met. The first cooperative can meet self-sufficiency only if it uproots some of the young and/or stumped coffee areas.

4. CONCLUSIONS AND POLICY IMPLICATIONS

As emerged from the past performance analysis of the cooperatives their existing land use pattern was found to be sub-optimal, especially in type one and two, and their income level is very low. Full adoption of the available technology would improve their net farm incomes, but does not ensure food self sufficiency in each case, i.e. technical efficiency is a necessary but not sufficient condition for the cooperatives' development. It has to be supplemented by improving allocative efficiency as well.

In the optimum cropping pattern of type one cooperative, where land is a very scarce resource, priority is given to move towards the goal of self-sufficiency. Instead, larger cooperatives (type two and three) can expand coffee plantations after meeting their subsistence requirements and thus substantially increase their cash income. Though shortage of working capital effectively constrained the expansion, the findings clearly indicate that constraints and optimal cropping patterns differ among the types of cooperatives, i.e. development strategies have to be adjusted to the individual conditions and must not be standardized. The optimum cropping patterns resulted in high labour peaks causing a need for campaign labour in the harvest months of October and November. Red cherry quota contributes desicively to the creation of sharp labour peak and consequently to external labour requirements.

In general, the optimal farm plans are relatively stable and some degree of variation in the red cherry quota policy, prices and yields does not affect cropping patterns. In view of the finding that the coopertives inadequately provided with productive inputs, not only credit facilities should be extened to them, but also the adoption of improved technology must be accelerated. Because of the variations among the economic behaviour of coopertives, farm planning should not only be macro-oriented, but also must give emphasis to micro-level economic indicators such as land-man ratio, resource availability, subsistence requirement etc. Adjustments in the existing cropping pattern in order to yeild higher incomes and to achieve focd self-sufficiency level calls for improved farm management extension. Finally, more research work is needed to alleviate the present lack of research information in the subsector.

REFERENCES

[1] Casey, H. 1974. Dynamic Programming in agricultural Production. Planning Agriculture in low income countries: A symposium. Department of Agricultural Econömics and Management, University of Reading, England, Development Study No. 14, pp: 101115.

[2] Childs, R.A. et al., 1983. A Dynamic Programming Approach to Apple Orchard Replacement. Department of Agricultural Economics, Agricultural Experiment Station, A.E. RES. 83 11, Cornell University, Ithaca, New York.

[3] Faris, J.E. 1961. On Determining the optimum Replacement Pattern: A reply. **Journal of Farm Economics,** 43 (4): 952 955.

[4] Hazell, B.R. and Norton, R.D. 1986. Mathematical Programming for Economic Analysis in Agriculture. Macmillan Publishing Agency, New York.

[5] Heady, E.O. et al., 1964. An Interregional Programming Model for Agricultural Planning in India. **Journal of Farm Economics,** 46 (1): 137-149.

[6] Hopper, W.D. 1965. Allocation Efficiency in a Traditional Indian Agriculture. **Journal of Farm Economics,** 47 (3): 611 624.

[7] Low, A.R.C. 1974. Decision Taking Under uncertainty. A Linear Programming Model of Peasant Behaviour. **Journal of Agricultural Economics,** 25 (3): 311321.

[8] Olson, R.D. 1986. Economics of Orchard Replacement. Giannini Foundation Information Service Series No. 1. University of California, Davis.

[9] Rae, A.N. 1977. Crop Management Economics. Granada Publishing Limited, London.

[10] Schultz, T.W. 1964. Transforming Traditional Agriculture, New Haven, Yale University Press.

[11] Sheehy, S.J. and McAlexander, R.M. 1965. Selection of Representative Benchmark Farms for Supply Estimation. **Journal of Farm Economics,** 47 (3): 981-695.

[12] Upton, M. 1976. Agricultural Production Economics and Resource Use; Oxford University Press.

[13] Winder, J.W.L. and Trant, G.I. 1961. Comments on "Determining the Optimum Replacement Pattern". **Journal of Farm Economics,** 43 (4): 939-951.

[14] Wong, J. 1971. Peasant Economics Behaviour, The Case of Traditional Agricultural Cooperation in China: **The Developing Economics,** 9 (3): 332-348.