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ECONOMIC OPTIMA IN RESOURCE ALLOCATION FOR SMALLHOLDER SUBSISTENCE FARMING IN GHANA

Dissertation for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY
YIADOM KWASI ATTA - KONADU

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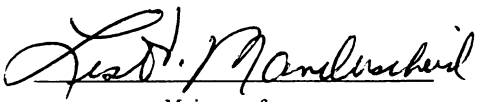

Major professor
Lester V. Manderscheid

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ABSTRACT

ECONOMIC OPTIMA IN RESOURCE ALLOCATION

FOR SMALLHOLDER SUBSISTENCE FARMING IN GHANA

By

Yiadom Kwasi Atta-Konadu

The primary objective of this study was to investigate optimal resource use for smallholder subsistence farmers--information needed to evaluate issues and emerging policies associated with smallholder producers of food crops in selected regions in Ghana. The major concern was to provide some insights into efforts necessary for expanding the productive potentials of the farms delineated in the study. The study was designed to interface with the maize improvement project of the Government of Ghana.

Specifically, the issues were: 1) resource utilization and profit maximizing plans consistent with initial resource endowments and expanded resource use; 2) competitive position of crops produced using new technology and crops produced in mixtures using indigenous technology; 3) dynamic interdependence between production, subsistence consumption and investment/disinvestment; 4) the use of on-farm storage of crops as additional means of increasing farm income; and 6) increased efficiency in labor utilization.

The methodology used included the use of static linear programming and poly-period linear programming to assess the income increasing possibilities for the representative farms by an optimum allocation of resources actually used by the farmers in the sample. The representative farms were defined by the level of technology of production and by the ability to adopt agricultural innovations. The analysis was conducted in three empirical phases and two types of representative farms located in five regions in the country, viz. Brong-Ahafo, Ashanti, Central, Eastern and Volta regions. Phase I was designed to investigate the optimal allocation of currently available resource using currently utilized technology. The Phase II model incorporated on-farm storage activities and allowed borrowing up to optimum levels instead of putting a restriction on the amount of money that could be borrowed. Phase III, the Phase II model was expanded to include parallel cropping activities representing two alternative advanced technologies of producing crops in pure-stand.

The data used were collected from a sample of 361 operating holders through intensive farm management survey carried out for a period of fifteen months during 1972-73. The holders were interviewed to obtain information regarding actual resource constraints facing them, the input-output relations encountered by them and food consumption.

Several important policy implications emerge from the findings of this study. First, on all representative

farms, the marginal value products (MVP's) of land and money capital were high, suggesting that increasing the use of these resources would lead to income gains. A large income increasing possibility was also indicated by large MVPs of agricultural inputs complementary to land such as labor, fertilizers, planting materials and farm implements. Regional variations in the magnitudes of the MVP's were indicated. Second, for all the representative farms mixed-cropping held a comparative advantage over pure-stand cropping, as shown by the magnitudes of the relevant shadow prices. The implication is that given the choice, the farmers would prefer growing crops in mixtures rather than in pure-stand--a situation that would appear to militate against the introduction of new technology and/or enterprise specialization. Third, the results indicate that organization of an adequate credit supply is the starting point of any program to encourage the farmers to increase resource use. Credit policy should aim at providing credit to the farmers taking into account expected returns, production and household consumption requirements rather than using arbitrary rules. Fourth, significant income gains can be derived by removing the bottlenecks that lead to under-utilization of agricultural labor. One policy option discussed is the provision of a network of feeder roads and an organization of mass transit services to serve the farming communities. Fifth, the results provide the basis not only for direction in general product and input policy

formulations, but also indicate the magnitudes by which relevant policy variables such input subsidies and guaranteed minimum prices could be manipulated to achieve specified development goals.

Major research needs highlighted by this study include: 1) an incorporation of stochastic factors such as weather variability and risk and uncertainty associated with the adoption of new technology; 2) an expansion of the periods covered in the poly-period model to more rigorously a) investigate the dynamic interdependence of between production, consumption and investment/disinvestment; and b) account for the full production cycle of crops such as cassava and plantains often left in bush fallow and undergo continuous harvesting over an extended period of years; 3) economics of mixed-cropping vis-a-vis pure-stand cropping; and 4) benefit-cost analysis of feeder road construction and the building and location of storage facilities. The macro-effect of storage operations on prices will need an investigation also.

ECONOMIC OPTIMA IN RESOURCE ALLOCATION FOR SMALLHOLDER SUBSISTENCE FARMING IN GHANA

By

Yiadom Kwasi Atta-Konadu

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To beloved R, Morya, Lanello and K-17,

my gratitude

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e 4.6. Model II Cash Flows Category II Farms, Brong-Ahafo Region.

Row No.	Column Name	Unit	Row Name	Start Cash	BORR1	CASH1	BORR2	CASH2	BORR3	CASH3	BORR4	CASH4	BORR5	CASH5	BORR6	CASH6	If Profit	RHS
1	objective function	¢	OBJ	-1	-1.06	0	-1.05142	0	-1.04285	0	-1.03428	0	-1.0257	0	-1.0171	0	1	= 0
2	cash on hand period 1	¢	CASHP1	-1	-1	1												= 0
3	cash on hand period 2	¢	CASHP2			-1	-1	1										= 0
4	cash on hand period 3	¢	CASHP3					-1	-1	1								= 0
5	cash on hand period 4	¢	CASHP4							-1	-1	1						= 0
6	cash on hand period 5	¢	CASHP5									-1	-1	1				= 0
7	cash on hand period 6	¢	CASHP6											-1	1			≤350
8	cash on hand period 7	¢	CASHP7												-1	1		
9	start cash	¢	CASHST	1														

Source: Computed from survey data.

Table 4.6. Model II Cash Flows Category II Farms, Brong-Ahafo Region.

Row No.	Column Name	Unit	Row Name	Start Cash	BORRW1	CASHD1	BORRW2	CASHD2	BORRW3	CASHD3	BORRW4	CASHD4	BORRW5	CASHD5	BORRW6	CASHD6	Π Profit	RHS
1	objective function	¢	OBJ	-1	-1.06	0	-1.05142	0	-1.04285	0	-1.03428	0	-1.0257	0	-1.0171	0	I	= 0
2	cash on hand period 1	¢	CASHP1	-1	-1	1												= 0
3	cash on hand period 2	¢	CASHP2			-1	-1	1										= 0
4	cash on hand period 3	¢	CASHP3					-1	-1	1								= 0
5	cash on hand period 4	¢	CASHP4							-1	-1	1						= 0
6	cash on hand period 5	¢	CASHP5									-1	-1	1				= 0
7	cash on hand period 6	¢	CASHP6											-1	-1	1		= 0
8	cash on hand period 7	¢	CASHP7													-1	1	= 0
9	start cash	¢	CASHST	1														≤250

Source: Computed from survey data.

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CHAPTER I

INTRODUCTION

Theories, policies and programs relating to agricultural development should be buttressed on empirical research. This study is an attempt in this direction. The lackluster record of agricultural development in Ghana, other than cocoa, could perhaps be blamed on its predominantly autochthonous system of farming that has over the years undergone very little change. Features of this system of farming are (1) subsistence production and subsistence food demand; (2) mixed cropping[1] and (3) structural manyness of smallholder farming. Under these conditions the key to agricultural transformation seems to lie in (1) fuller commitment of the indigenous farmers to the money economy; and (2) an analysis and understanding of the conditions under which production by the smallholder subsistence farmer can be improved and made more profitable to organize.

Since Ghana's independence in 1957, the general direction of its agricultural policy has remained virtually the

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[1]The category of mixed-cropping mentioned here should be distinguished from mixed farming commonly practised in India, Pakistan and other areas. Mixed-cropping used in this context refers to the planting of two or more crops at random on a plot of arable land.

same: production of food to feed the people and raw materials for industries and the promotion of export crops to earn foreign exchange. However, we have witnessed kaleidoscopic changes in programs to give effect to the policy. From Nkrumah's socialist approaches to agricultural development to the turnabout and rhetoric about the efficacy of the private enterprise system under the National Liberation Council (NLC)[1] and Busia's regimes and now, to self-reliance--the epitome of the National Redemption Council (NRC)[2] Operation Feed Yourself. In all the discussions, theories, concepts and schemes adopted to implement agricultural policies, there has been a considerable lack of information about the most important form of agriculture in the country--i.e., smallholder farming--information needed to evaluate issues and emerging policies relating to the smallholder producer.

Nature of the Smallholder Problem

Ghana's agriculture is predominantly composed of smallholders. In the 1970 census of agriculture it was estimated that out of 805,200 holdings, 81 percent were smallholder operators.[3] The 805,200 holdings had an average

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[1]National Liberation Council (NLC) (February 1966-September 1969).

[2]National Redemption Council (NRC) (Since January 1972).

[3]See Report on Ghana Sample Census of Agriculture 1970, Vol. 1, 1972.

size of 5.6 people resulting in estimated farm population of 4,517,800 people or roughly 50 percent of the total population of the country.[4] Of the holders, 30.6 percent cultivated less than 2.0 acres, 54.7 percent less than four acres and 81.9 percent less than ten acres. Only about 18.1 percent of the holders cultivated ten acres or more. The census report also provides information on the extent of commercial orientation of the farmers. Out of 805,200 holders, 11,110 (14 percent) were classified as producing for subsistence only, while 289,700 (36 percent) were classified as mainly subsistence and 404,400 (50 percent were operating mainly for sale.[5] These two features--smallholder farming and subsistence production--interact with mixed cropping to produce unique problems related to low labor productivity, low land productivity, food shortages, rising food prices and economic environment which has shown itself uncongenial to accelerated mechanized farming. The following questions can be raised in respect of the seemingly poor performance of the smallholder subsistence farming: (1) is the cropping system

---

[4]Estimated at 8.5 million.

[5]The definition used for the classification were as follows: (a) operated for subsistence only--no cash crop cultivated and little or no sale of food crops, (b) operated "mainly" for subsistence--more than 50 percent of produce intended for home consumption and, (c) operated mainly for sale--more than 50 percent of produce intended for sale.

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responsible for the poor performance; (2) what are the objectives of the smallholder farmers; (3) are the resources available to them optimally organized when measured by the objectives of farming and prevailing state of arts' and (4) to what extent is the production potential utilized within the framework of existing pattern of smallholder farming? Answers to questions such as these provide insights into the conditions under which smallholder farming in Ghana can be restructured to make it more profitable and also point to the factors which constrain the attainment of goals defined by the farmers themselves.

Dimensions of the Smallholder Problem

In this thesis, we shall attempt to look at the present capacity of subsistence production and examine the production alternatives and the possibilities for expanding production capacity via increased efficiency in resource use. In Ghana today, not only food, but also fibre requirements seem to be outdistancing the capacity of the agricultural sector to produce them. To understand why this is so, one has only to examine the country's major constraints to agriculture. Constraints have different ramifications which are pertinent to the discussion that follows.

The root causes of insufficient supply could be attributed generally to such perennial constraints as a generally low level of technology, lack of price incentive,

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small size of farm and insufficient resource base including capital, managerial know-how, labor and land. These can be considered as constraints of "nature" and could limit production capabilities. There is another type of constraint which can be considered as self-imposed and would needlessly limit production capacity also.[6] The most outstanding and limiting of these self-imposed constraints are: (1) socialist policies which in previous regimes in Ghana neglected the improvement of peasant farming; (2) subsistence farming and mixed-cropping; and (3) "Operation Feed Yourself" (OFY) as a modus operandi.

In a food shortage situation, "self-reliance" or "Operation Feed Yourself" can become an asset if adequate attention is initially paid to the crucial issue of laying the groundwork for long-term agricultural transformation of the economy, rather than relying on uncertain moral suasion to achieve quantitative targets in food production

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[6]Following G. K. Helleiner [1969], self-imposed constraints are used here to reflect certain political, social or economic rules or objectives which are to guide or constrain one's development policies. A constraint on rules blocks off a range of possible alternative policies. The fact that the producers persist in adhering to their old rules of production--mixed-cropping and subsistence production--they shut off other alternatives of production such as specialization and this behavior can be regarded as self-imposed.

The socialist policies under Nkrumah's regime and the "Operation Feed Yourself" are clearly self-imposed constraints. The rules followed are political ones and they do block off a range of possible policies.

irrespective of the cost. If development efforts echoed by the OFY are backed by research and experimentation, long-term gains can be expected.

The critical issue facing smallholder farming in Ghana is that of carefully examining production alternatives and increasing the efficiency in the resource use in order to expand the present capacity of agricultural production. This point has forcibly been brought home by the present regime which has been reminding the people that their "survival depends largely on their ability to utilize fully the rich agricultural endowments of the country" [Ministry of Agriculture, 1972, p. 1]. Thus, honest appraisal of the abundant opportunities at hand for farming reaffirms the belief that the economy seems to have at its disposal the elements necessary and sufficient for solving its problem of rising food prices. The question of considering the possibilities of increasing farm returns through reorganization of the available resources and enterprises appears to lie at the heart of the problem. Therefore, it would seem that a fuller utilization of the matrix of the present, through the commitment of the producers to commercial production, appears to be a sound approach to the solution of our farm problem and this disposition must dispel any tendency to put off until the morrow that which needs attention today if that morrow is to become a desirable

reality.[7] The popular presumption that the possibilities of such a reorganization are non-existent in a country like Ghana, is untenable. One can always point to Japan where, in the early days of its agricultural transformation, the farmers, even though lacking in capital resource (the most limiting resource), were still able to increase their efficiency and earnings by utilizing the surplus labor and other resources. These farmers used more surplus labor with very little capital, the principal increase in resource use emanating from a more complete utilization of unpaid family labor.

This study seeks to explore the possibilities of such developments in Ghana. Operating within a modified framework of the self-imposed constraints referenced above,[8] the study is designed to make some modest contributions to our understanding of the problems of smallholder farming in Ghana and also provide the missing links in the chain of knowledge and information needed to rationally formulate product and input policies at both the micro and macro levels.

The Objectives

The objectives of this study are:

1. To analyze the organization of subsistence

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[8] An example will be the incorporation of economic calculations into the self-reliance policy. Such an approach might help prevent tying up scarce resources in unproductive investments. In other words, the principle of comparative cost or advantage should not be needlessly sacrificed on the alter of self-reliance.

farming in the major maize growing areas in Ghana so as to assess and appraise the economics of present resource use and the requisites for increasing agricultural output and farm incomes.

2. To determine the efficiency of resource utilization and profit maximizing plans consistent with the initial resource use, expanded resource use and technology of the categories of farming identified in the survey.
3. To determine alternative technological potentials for producing farm output, which can be considered by the extension workers in their innovation diffusion efforts.
4. To evaluate the potential of the various policy instruments, such as product and factor prices, interest rates,on-farm storage, etc., which could be used to bridge the gap between actual and potential production and thus provide the framework for policy manipulations desired to achieve expanded food production and farm incomes in an optimal fashion.
5. To demonstrate the methodological reasonableness and efficacy in using linear programming techniques to examine the dynamics of on-farm storage of crop output with consideration given to consumption withdrawals for family subsistence needs.

Policy Issues Arising Out of the Problems of the Farmer

With the notable exception of maize, rice and beef, practically all the major food items consumed in Ghana are produced in the country. Expanded food production is needed to feed the expanding population adequately and nutritionally, both in the urban and rural sectors of the country. In the rural areas, food consumption patterns tend to be prescribed by availability, i.e., by what types of crops are grown in the vicinity. For instance, although maize growing occurs in all the study areas, it is only the main staple in three of the areas: Eastern, Central and Western regions. However, with increasing trends towards urbanization near the food growing centers, it becomes necessary, not only to diversify to expand the scope of product mix in each region, but also to improve upon the distribution system to insure minimum delays in moving products to deficit areas. The market structure and the general pricing mechanism must be such that any long-term changes in food prices are quickly passed onto the producers and consumers without the "mammy truckers,"[9] and "forestallers"[10] or the various intermediaries

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[9]The expression "mammy truckers" refers to the urban market 'mammies' or wholesalers who integrate backwards to run food transportation operations.

[10]The forestallers provide a link in the distribution chain between producers and urban wholesalers--or the market mammies.

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absorbing a disproportionate share of the accruing benefits.

Agribusiness enterprises, which deal with the production of cassava chips, yam chips, plantain chips and certain convenient foods (i.e., instant yam "fufu," instant cocoyam "fufu" and instant plantain "fufu"[11]) are becoming increasingly important in the country. There are promising markets, both domestic and foreign, for these items. This trend should encourage parallel expanded production in the food system. It would appear that the goal of agriculture, looked at from the viewpoints of both the producers and the government, is expanded food production to match effective demand. In this study, we shall direct our attention to how this can be accomplished through more efficient utilization of resources and the selection of appropriate policy programs whose implementation can help increase the overall performance of the agriculture. In order to obtain a good perspective of the relevant policy issues, we shall examine here specific consequences of the farmer problems and match them with the corresponding policy programs. This will set the stage for directing our empirical analysis in this study and the policy implications that will emerge.

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[11]"Fufu" a popular prepared food made from either plantain, cocoyams, yams or cassava or from a combination of yams and cassava, plantains and cassava and cocoyams and cassava in certain subjectively determined fixed proportions.

Scale of Operations

In any economy where there is not much fixed investments on farms in the form of buildings, land improvement structures, etc., farm size in the form of planted acreage is a reflection on the economic well-being of the farmer. Income flows from farming are typically allocated between family consumption and reinvestment in the farming operations as a basis for the generation of later income and consumption.[12] Thus, the ability of the small-holder farmers to generate these income flows is severely limited by the smallness of acreages farmed. With increasing population pressures, the tendency to persist in cultivation of small acreages may lead to what Clifford Geertz [1963] has termed "agricultural involution."[13] Alfred Dadson [1970] raises the question as to why the peasant farmers in Ghana cultivate such small areas if land is generally not scarce. Despite the popular views to the contrary, the tenurial arrangements as they exist in the project areas do not seem to constrain the ability of willing farmers to

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[12] See Nakajma [1957, 1965], Mellor [1965a, 1965b], I. J. Singh [1968], Wharton [1969] for a discussion of the farm-household interdependence. In a recent article by Lau and Yotopoulos 1973 , this interdependence has been referred to as "non-block recursiveness".

[13] J. Dirck Stryker [1972] shows the reaction of peasant farmers to the increase in population density. In some cases, such as Java, he shows how food production was maintained by continually increasing labor intensive techniques, while the marketed surplus was decreased--a process termed "agricultural involution."

expand their acreages [Ollenu, 1971] and [Min and Fagger, 1971]. Nor is the notion of limited aspirations on the part of the farmers a good enough culprit since the literature documents several instances of peasant farmers responding to economic incentives [Schultz, 1964], [Chennareddy, 1967], [Hopper, 1965]. Rather the answer lies in what Dadson[1970] has termed

> ". . .the system of resource organization in indigenous farming: The extensive and discontinuous pattern of land use, the heavy dependence on labor and the limited use of capital inputs."

To help resolve the scale or resource proportionality problem the government has on-going programs to organize the farmers into cooperatives and to offer subsidized land clearing services to the farmers. In this context, an important policy consideration as we shall see below is that of providing money capital at low rate of interest to the farmers.

Money Capital

The production cycle of the crops covered in the study can be grouped into four stages: (1) clearing and preparation of land; (2) sowing, planting and fertilizing; (3) cultivation--weeding and (4) harvesting. Each stage of the process requires capital, but the banks normally on their own will not provide credit to finance all the various stages (in practice, they choose the stage or stages at

which the capital sum advanced would (a) "be utilized to the optimum advantage to both parties, i.e., lender and borrower; and (b) be easily recovered with interest." [J. E. Yeboa, 1968, p. 4]).

However, both "lender and borrower may put different interpretations to what the "optimum advantage" implies, especially with respect to the timing of borrowing and repayment. The government has responded to the situation by providing generous, across-the-board, low-interest loans to the farmers. In spite of the availability of the government credit facility, one of the major complaints of the farmers interviewed was their lack of access to institutional loans. Where the loans were accessible, the rigidities in the bank's or government's lending requirements--such as collateral and minimum acreage requirements (criterion)--disqualify a majority of the farmers.[14] The alternative to this type of loan is obviously noninstitutional money lending which invariably carries very high interest rates.[15] This study will attempt to investigate the effect of interest rates on farm organization and the

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[14]To qualify for a loan, a farmer must be cultivating at least six acres. Referring to the census data in the Census Report, this implies that about 67.8 percent of the holdings in the country will be disqualified because they cultivate less than six acres.

[15]Loans for traditional money lenders are normally carried for a short period. The high interest charges reflect the transaction cost and risk premium.

extent to which the timing of borrowing during the crop production year can change the character of other limiting resources.

Storage and Timing of Sales

Because of the extent of seasonal price movements, the farmers have an opportunity of increasing their gross revenue without necessarily increasing physical yields. This can be accomplished through storage activities in order to time marketing of their produce to the periods in which maximum gains can be obtained. The government has extension programs in operation to help the farmers in the techniques of storing their produce--including the types of structures to use and the necessary steps needed to minimize storage losses. The dispersion of marketing and distribution facilities in the producing areas also ensures that the farmers always have a ready market for their produce.

Accessibility to Farms

The average farmer in the study areas resides about one-half hour walking distance from his land. The consequences of this are manifold: (1) in one production year, several days are committed to walking which otherwise could be used working on the farm; (2) a heavy rainfall that starts early in the morning and continues to about 10 a.m. may put the farmers out of work for the whole of that day;

or (3) a mid-day heavy downpour, even for a brief period, might abort working efforts for the rest of the day.

Since the hours spent in walking compete with available hours for direct production efforts, it is conceivable that a reduction in the walking hours would contribute positively to expanding the scale of farm operations. To do this within the context of village living, feeder roads have to be constructed and mass transit services be provided at a cost less than the marginal value product of an hour of labor used in production. This study will look into this aspect of the farm problem.

Input Supply and Product Marketing

Insufficiency and nonavailability of inputs such as improved seeds, farm implements, fertilizers and other agricultural chemicals contribute to low crop yields. Related to the question of input supply is the diffusion of these new inputs and the techniques of their use to the farmers. Inadequate marketing facilities give rise to product price fluctuation, thereby affecting levels of production. The next section outlines the steps being taken by the government and aid[16] agencies to correct these difficiencies.

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[16]The USAID Office in Ghana has been making substantial contribution through research and extension and direct financial aid in supporting programs in this area.

Production Campaigns to Expand Food Output Capacity

There are two outside agencies operating special programs with the support of the Ministry of Agriculture: the USAID Focus and Concentrate program and the UNDP Project for "Increased Farm Production through Fertilizer Use," usually known as the "Ghana 20" Project or the "FAO Fertilizer Project." The aim of the Focus and Concentrate Project is to focus extension effort on a few farmers and to concentrate resources on them so that extension is not frustrated by the farmer's inability to acquire input. Two of the study areas--Kpandu and Somanya in the Volta and Eastern Regions, respectively, are beneficiaries of this project. Participants in the project are chosen on the basis of their willingness to cooperate and their access to tillable land. For each selected participant, a farm plan is prepared showing (a) farm layout, (b) crop rotation, (c) estimated labor requirements, (d) requirements of seed, pesticide, fertilizer and equipment including custom-hired machinery services, a calendar of farm operations, a farm budget and an achievement report. It is hoped that the perceived success of these farmers will be an effective way of diffusing agricultural innovations to their peers. The FAO Fertilizer Project includes not only all aspects of fertilizer use (through the laying out of demonstrations and trials in all parts of the country),

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but also deals with processing and marketing, the introduction of improved seed varieties, storage and better cultural practices.

Two other related production campaigns are the Crop Improvement Projects for maize and rice and the Operation Feed Yourself. The Crop Improvement Projects are still on the drawing board and this study is reckoned to make some contribution to the maize project. Details of those projects can be seen in the following documents: "Proposal for a Maize Development Project in Ghana" [Ministry of Agriculture, 1971] and "Proposal for a Rice Development Project in Ghana" [Ministry of Agriculture, 1971]. The Operation Feed Yourself campaign started in 1972 as an emergency program or a rescue operation to quickly bring some temporary solution to the food deficit situation. The early successes have convinced the government that it can be used as a long-term development strategy.

Specific Program Instruments

The basic program instruments currently in use to further the objects of all these production campaigns are: (1) guaranteed minimum prices for maize to start with, but the government is presently considering expanding its scope to include other major food crops, such as yams, cassava, plantains, cocoyams and rice; (2) fertilizer subsidy, (3) subsidy on farm implements, such as machetes and (4) subsidizing the purchase of improved seeds and ensuring their timely distribution to the farmers.

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Concluding Remarks

Besides enlarging the scope and content of optimum resource organization analysis, it is the purpose of this study to simulate the varied effect of policy decisions in the project areas by relating these decisions to the micro-economic aspects of decisions with regards to:

1. Acreage expansion due to the provision of facilities for the farmers to clear more acreages for production.
2. Changes in infrastructure such as the provision of feeder roads and public transit services to cut down on the amount of time spent walking to farms.
3. Changes in the provision of credit--in amount, rate of interest or timing of borrowing.
4. Changes in the subsidized prices of inputs such as fertilizers and other chemicals and,
5. Changes in output prices to evaluate the impact on farm income of different levels of guaranteed minimum prices.

The effect of policies and other changes will be analyzed according to how they affect opportunities facing the representative farmer.

CHAPTER II

RESEARCH STRATEGY

The general research approach for this thesis project makes use of a farm sample survey, static linear programming and poly-period linear programming. The details of the sample survey and the analytical techniques used will be presented in this chapter. Chapter III will describe the areas studied and the selection of representative farms to which the analytical procedures will be applied.

Analytical Approaches

In Chapter I, it was pointed out that the smallholder problem receiving attention in this study centers around resource mobilization and allocation. The by-products of the allocative problem are the issues associated with supply responses and farm adjustment. There are several analytical techniques available to researchers seeking answers to such problems.

Among the several techniques used are: (1) linear programming in its multi-faceted forms; (2) budgeting; 3) aggregate time series analysis, (4) marginal analysis nd (5) simulation. These are not exclusively used, but ach can be used in combination of one or more of the others.

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In general, however, the choice of an analytical technique depends, most importantly, upon the availability of data, the purpose for which the model is intended and the nature of the structural coefficients being sought to elucidate a particular problem.

Linear programming is the approach used in this study. Its most important advantage lies in the fact that it is highly suitable for estimating supply functions and analyzing farm adjustment problems in an environment where no time series data exist. Simulation, generally, is a promising tool in such an environment and, perhaps, may provide the most feasible approach for analyzing the farm problem, particularly under imperfect knowledge as programming components and logical parts of simulation [Hart, 1967]. Budgeting is an alternative useful approach for assessing the relative profitability of different farm plans. However, its relevance lies in the availability of a sufficient number of farm plans to be evaluated.

The General Approach

The analytical techniques used to accomplish the objectives of this study involved the use of linear programming and cash-flow analysis within the framework of poly-period programming. The procedures involved in carrying out the study included: (1) surveying specified farming areas in five regions in Ghana; (2) using the sample data to define representative farm resource situations; (3)

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constructing a structural framework for the linear programming models by determining the technological coefficients, the operational constraints and the activities or processes; (4) programming the representative farms in three phases and; (5) analyzing the factors which determine the effectiveness of given policy measures. The general approach will be elaborated in Chapter IV of this thesis.

Sources of Data

In Chapter I, the problem and objectives of this study were delineated. In order to answer the questions raised and to accomplish the objectives it was necessary to collect and assemble the data needed to analyze and meaningfully interpret the situation.

Data Collection

Data were required on farm organization, production, food consumption and resources. These data were collected by surveying farmers located in the study areas.

The sample population was designed to include farmers in the specified areas who were producing maize in pure-stands or in mixtures with other crops. The population was prestratified on the basis of geographic area so as to incorporate differences in soils, vegetation, climate, type of farming and urban influences. The five areas selected were the geographic areas earmarked by the Ministry of Agriculture for the location of the Maize Crop Improvement Project.

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The sampling rate was suggested by an ad hoc committee created by the Ministry of Agriculture comprising of representatives of (1) the USAID Office in Ghana; (2) the Ford Foundation staff; (3) Harvard Development Advisory Service staff and (4) the staff of Ministry of Agriculture. Because the farms in each geographic area were assessed to be homogeneous in many characteristics such as the literacy levels of the farmers, farm size, cropping patterns, and technical know-how of the farmers, it was the general concensus of the committee members that approximately 50 holdings in each area would be fairly representative of farming in the areas.

In the selection of farms and in the data collection procedure in each area a multi-stage sampling approach was used: (1) probability sampling of enumeration areas within the agricultural districts earmarked for the Maize Project; (2) probability sampling of holdings using nonuniform sampling plan, i.e., one that differed primarily as to the sampling fraction used in each area, and (3) random location of plots of prescribed dimensions in the fields for conducting the crop yield study.

Within each selected enumeration area there was a complete enumeration of holdings from which the sample was drawn. The following table shows the number of holdings enumerated by sample area, the sampling fraction applied to each region and the size of the sample.

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Table 2.1. Selection of Holdings.

Region	Holdings (Number)	Sample Fraction (Percent)	Minimum Sample Size (Number)
Brong-Ahafo	2,369	3.0	70
Ashanti	2,797	2.5	70
Volta Region	1,137	6.2	70
Eastern Region	356	19.7	70
Central Region	919	7.6	70

Twenty extra holdings were selected for each area to act as replacement for noncooperators.

A statistically efficient procedure used was to rank and group the five areas on the basis of the number of holdings in each area. The larger the number of holdings in each area, the smaller the sampling fraction used. This procedure was meant to equalize the size of the sample for each area and thereby provide a comparable level of sampling precision among the areas. The following steps in the data collection process were involved.

1. The first stage consisted of designing the sample and the questionnaire; pretesting the questionnaire; effecting the necessary adjustments; selecting and training secondary school leavers for the enumeration work.
2. Interviewing using open-ended questions to collect information on major resources, enterprises, farms and their location.

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3. Area measurement using tape and two inches prismatic compass. Fields farmed during the previous three years were identified and measured to constitute the stock of unused land.
4. Yield estimation using the classical method of crop yield estimation by means of density plots.
5. Visiting each farm-household twice a week to collect data on food consumption, purchases, sales, gifts, age, sex and size of the farm household and income, for a period of 12 weeks.
6. Coding, tabulating and computer services: after the schedules were compiled and the area measurement, yield study and consumption survey completed, the enumerators were assembled for a period of two weeks to be trained to code the data. Later, the data was punched and put on a tape to be sent to Michigan State University. The linear programming computations were carried out on the CDC 6500 using a combination of Harsh/Black program and CDC Apex-I program at Michigan State University.

Analytical Models

The linear programming model in this study was carried t in three major phases. On an individual basis, a farmer y increase his income by (1) adopting modern production thods as opposed to the traditional technology; (2) seeking

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d selecting the most feasible combination of activities to termine the higher profit plan to be adopted by the farmer; d (3) adjusting the size of the farm business as indexed the size of cultivated acreage. The LP models were used explore the individual alternatives to suggest guidelines farm reorganization and to point to the magnitude of the ritical resources required for the change.

Phase I

Included activities for different cropping enterprises ere three types of labor activities, input purchasing, orrowing, food buying and product selling activities. Land, abor, operating capital, borrowing and consumption were ixed at the levels indicated by the survey data for the epresentative farms. In the initial programming analysis, learing of unused land was not an alternative, the first bjective being to determine optimum farm plans for each epresentative farm with the existing acreage. Later, the arms were reprogrammed with the added alternatives of land learing and resource expansion. The idea being pursued as to determine whether changes in resource use on existing cres would yield more or less profit than changes in resource se including additional acreage.[1]

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[1]The predominant cropping system found in the study reas was that of shifting cultivation. Under this system ew land (mostly secondary forest) is brought into cultivaon each year while the farm land of the previous year is ft behind, though because of continuous cropping of crops ke plantain, cassava and cocoyams, the bush fallow land

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Phase II

In Phase II, linear programming techniques within a -period framework of analysis was used to incorporate flows, storage and additional land clearing. A plan- horizon of one crop year was used and was divided into n periods to coincide with the major farm operations.

Phase III

This phase was used to determine what the farmers it to do to maximize their incomes. This phase is an nded version of the Phase II model. Alternative tech- gies for continuous cropping were incorporated into the el by adding additional rows and column activities. The nological coefficients for the continuous cropping were ved from existing experimental data. In the selection mproved production methods, the problems associated the adoption of innovations which incorporate hastic factors were not considered.

Concluding Remarks

The focus of this thesis is on optimum resource organi- on of smallholder subsistence farming in Ghana. To mplish the objective of the study by means of a con- ration of possible adjustment activities, data on the

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eriodically maintained and the crops are harvested.
ng the survey, farm land of the years 1971, 1970 and 1969 identified, measured and crops still found on the land rded. In isolated cases, a piece of land was observed vated for two years in succession under maize in pure- before introducing crops like plantain, cocoyams and va in mixtures.

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CHAPTER III

AREAS STUDIED

The sample survey was carried out in the areas selected
Ministry of Agriculture, Ghana, for the proposed
ated crop improvement project for maize in the country.
Five regions; Ashanti, Brong-Ahafo, Eastern, Central
lta, are involved in the project operated by the
ry of Agriculture to promote the use of a yield-
sing package of inputs among the maize producers.
mple enumeration areas for this study were drawn from
llowing agricultural districts: Wenchi and Atebubu
ng-Ahafo region: Mompong and Ejura, in Ashanti
; Kpandu in Volta Region; Asesewa in Eastern region
edru in Central region.

The Ministry of Agriculture Study reports the following
ia for the selection of the project areas [Ministry
iculture, April 1971] from which the sample farms
elected: (1) existence of a sizable market-oriented
production;[1] (2) suitable soil and climatic conditions

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[1] A year round rural marketing activities are carried
the project areas. Wholesales or "mammy" truckers
e urban center converge at these marketing centers
twice a week to do business. The farm gate prices

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r the growing of maize; (3) existence and performance of -going programs dealing with maize production; (4) proxi- ty to major consuming centers and general state of transport cilities; and (5) existence of/or good prospects for the velopment of a package of improved practices which will gnificantly improve net returns per acre. (6) Evidence at the existing land tenure situation would not constitute significant barrier to the adoption of improved practices.

Similar Features of the Areas Studied

Demographic Characteristics

Appendix Tables D.1 to D.5 provide the demographic file of the population in the sample areas of the five ions studied. In all the areas, occupational distribu- n of the age-sex cohorts shows that for both sexes in the orts, age 15 and above, agriculture is the predominant upation. Nonagricultural occupations of employed persons the project areas include: (a) workers in transport and munication; (b) craftsmen, production process workers, vice, sport and recreation workers; (c) professional, nnical, administrative, executive and (d) managerial,

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commodities or the prices actually received by the farmers the rural wholesale prices on these markets less the cost transporting the commodities to the markets. Local whole- ers also buy at these markets, to be sold later at retail es, i.e., prices at which the local people can buy the nodities for direct household consumption.

The rural markets of national significance are Asesewa, lru, Kpandu, Mampong/Ejura, and Wenchi/Atebubu in the tern, Central, Volta, Ashanti and Brong-Ahafo regions, pectively.

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erical workers, sales workers. These jobs provide alter-
ive employment opportunities for the farm workers and
ir availability enabled us to incorporate family labor
ling activities in the LP model. Self-employed occupa-
ns identified were: tailoring, petty-trading, crafts
luding weaving and manufacturing of baskets, farm imple-
ts (such as hoes) by blacksmith, goldsmithing and
ving as a retainer to a local chief--something that
vides no direct pecuniary reward.

Climate

The sample areas have similar climatic conditions
respect to the intensity and timing of rainfall during
year. Two rainy seasons--April-July and September-
mber, are common to the selected sample areas.

Because of the greater intensity and longer duration
ainfall during the major season, March to August, the
r agriculture activities are concentrated in this period.
short duration and lower level of rainfall during the
r season (September-November) render this period less
able for crop production. Maize is the only crop of
rtance which is grown during the minor season. Its
d is, however, lower than for major season yield.

Contrasting Features

Soils

The real differences between the sample areas are soils
vegetation, farm sizes, crops predominantly grown,

Table 3.1

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e 3.1. Rainfall Profile in Project Areas in Inches.

Sample Area	Annual	Average (Major Season) April-July	Average Minor Season Sept.-Nov.
a-Ashanti	56.64	25.74	20.1
ampo-Brong-Ahafo	61.68*	28.76	21.98
e-Volta	65.12	28.39	22.41
ru-Central	51.61	26.64	13.57
ridua-Eastern	57.12*	25.5	17.51

tions adjoining or in fringes of sample areas.

e: Ministry of Agriculture, op. cit., 1971, Annex Table 2.

ugh the major soil type, savanna ochrosols, predomin-
in all the project areas, there are varying amounts of
resence of integrades of other soils, such as ochrosols
round water laterites in Ashanti, Brong-Ahafo and the
areas; and lethosols and ochrosols/lithosols in
ya area, Eastern Region and in Swedru area (Central
n). Ochrosols are considered quite satisfactory for
production, while the integrades are satisfactory,
ess desirable. The presence of these integrades in
ng amounts reveals sharp differences in soil fertility
en the regions, thus justifying the aggregation of
in each area where there are fairly homogeneous
characteristics.

Vegetation

An added factor that provides a distinction between
roject areas is that of vegetation and associated

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raphy of the land. The latter has something to do with sibility and the amenability of the land to mechanized clearing operations. Land clearing constitutes a major ment in the entire farming operations. The total ment involved in clearing an acre of land varies from gion to another and is a function of the type of tion and to some extent the topography. These features le another justification for aggregating farms within r vegetational categories.

Size of Farms

Three of the study areas, viz. Volta, Central and n regions are closer to important food consuming s. This factor, coupled with higher population ies in these areas and less availability of arable has resulted in less land cultivated per acre than in maining two regions--Ashanti and Brong-Ahafo. Using res as the cut-off point--the level below which the s are unwilling to lend to the farmers--the Ministry iculture census data report the following size dis- ion of holding six acres or less:

ng-Ahafo	54 percent of the overall holdings
anti	58 percent of the overall holdings
tern	75.4 percent of the overall holdings
tral	78.8 percent of the overall holdings
ta	82.8 percent of the overall holdings

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itutional arrangements and market conditions, they may
er in their objective functions [Sen, 1966].

Predominant Crops and Consumption Patterns

Although the six crops covered in the study--viz.
e, cassava, plantains, cocoyams, yams and pepper--are
n in all the regions, mainly in mixtures of two to six
s, the regions differ in the frequency of occurence of
crop in each region. Because of farm-household inter-
ndence, home food requirements tend to dominate the
sion of the farmers as to what crops to grow. Farmers
he study areas in the Volta, Central and Eastern regions
heavy consumers of maize and cassava products. The
crops consequently dominate the decisions regarding
ems in the regions. In addition, yams are next in
rtance in the study area in the Volta region; cocoyam
plantains next in importance in the Eastern region and
ain next in importance in the Central region. In
rast, yams, and plantain feature predominantly in the
of the farmers in the study areas in Brong-Ahafo and
ti regions. While, with the exception of few farmers
row maize in pure stand, crop specializaton per se is
icuously absent, the historical food consumption
rns in the study areas and the available market for the
ant crops, are important determinants of the types of
grown in each study area. It is expected that the

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programming model used in this study will capture
lative comparative advantage of the crops to grow in
f the study areas.

Urban Influences

The study areas in the Central, Eastern and Volta
s are much more influenced by urbanization than are
in the areas in Ashanti and Brong-Ahafo regions. The
s effect of the urbanization factor is higher prices
the producers in the areas located closer to important
ing centers receive for their produce.

Remarks

The differences in soils, farm sizes, cropping patterns,
ical consumption patterns and the influence of urban-
n provide the necessary justification for analyzing
eparately in each region. Accordingly, geographic
nstitutes the first stage in the construction of the
ntative farms.

Implications of These Characteristics for The Selection of Representative Farms for the LP Model

Introduction

ithin each geographic area there are certain features
agriculture present. At one extreme it is charac-
by a highly mechanized commercial enterprise,
ng large holdings owned by individuals or corporate
such as the State Farms Corporation, Food Production

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oration and Settlement Farms Division of the Ministry griculture. At the other extreme is found the tradi- al, subsistence, unmechanized operation, involving small ings that make little or no use of modern agronomic ts. In between, there is a third category--transitional culture, which makes limited use of modern inputs, such mporved seeds, fertilizers, insecticides and recommended ural practices. The survey excluded the highly mechanized s and included the other two categories of farming, and s around these technological categories that the repre- ative farms are selected. In addition to the farmers in category being homogeneous in certain attributes, such ge, cosmopoliteness,[2] functional literacy and historical ne levels, the two operational categories identify ng abilities of the farmers to expand or innovate.

Classification of the Sample Farms by Technological Category

Farms which used fertilizers, improved seeds and other ing materials as well as other chemicals and had had sion worker contact within 12 months of the study were ified as Category II farms. Farms that used mainly tional technology of production with no extension agent ct were classified as Category I farms. The number of within each category are shown in Table 3.2.

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[2] Cosmopoliteness is a communication term used to desig- the degree of exposure of a traditional person to the de world through travels, readings, personal contacts,

Table 3

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. Percentage of Farms by Technological Category in Sample Areas.

	Category I (Number)	Percent of Sample Farms	Category II (Number)	Percent of Sample Farms
Fo	54	76	19	24
	52	72	20	28
	71	100	0	0
	58	78	16	22
	53	75	18	25

Representative Farm Characteristics

e farms in each area were subdivided into two groups--
nal farms and transitional farms. Data from farms
o these two technological categories were used to
e the initial resource restrictions which define
esentative farm situations. The resource constraints
istical averages of the resources used by the farms
n the technological category classification. In
, the initial resource situation is based on the
ta as shown. The resource levels of Brong-Ahafo
ti sampling unit farms appear to be higher than
nterparts in other regions as reflected by acres
rm labor by man equivalent (ME) and operating capital.
classification of the sample farms into traditional
itional farms (i.e., Category I and Category II
spectively) was a post enumeration exercise. All
y farms in the Volta region were Category I.

Salient Features of the Farms in Five Regions: Brong-Ahafo, Ashanti, Eastern, Central and Volta.

s	Region								
	Brong-Ahafo		Ashanti		Eastern		Central		Volta
	Trad	Improved	Trad	Improved	Trad	Improved	Trad	Improved	Trad
	54	19	52	20	58	16	53	18	71
n (y)/	6.79	15.52	2.82	3.33	2.27	3.22	3.79	1.46	2.0
d/	6.22	23.23	6.03	5.82	3.43	3.21	3.38	3.51	
1)/	6.675	17.34	3.75	4.20	2.95	3.22	3.58	2.41	2.0
n	3.0	5.77	2.0	2.0	2.0	2.5	2.5	2.0	1.75
s									
rm	4.08	5.028	2.97	2.93	3.01	3.09	2.68	2.4	2.689
a	.61	.2899	.792	.696	1.02	.96	.75	.9987	3.458
a	1.636	3.4495	1.26	1.44	.98	1.04	1.3346	1.0013	.289
r	112.0	344.0	48.0	54.0	11.86	20.76	32.75	26.9	6.0
c/	16.78	19.84	12.8	12.85	4.02	6.44	9.12	11.16	7.69
/	125.19	250.0	107.8	87.0	69.63	125.02	103.65	74.61	27.0
	18.75	14.42	28.75	20.7	23.6	38.82	28.87	30.95	35.86
tion/Household									
)	.8381	.8231	1.03	.9	1.95	2.39	1.91	1.65	5.13
	.075	.08	.07	.09	.2	.2	.2	.2	.52
)	3.74	3.03	3.56	3.4	4.5	4.67	5.55	4.8	7.02
	59.0	58.52	84.0	116.36	47.0	54.0	34.96	32.5	45.2
)	4.88	4.33	4.9	5.6	6.9	7.3	1.76	2.4	1.9
	.98	.943	1.55	1.55	.62	.7	.26	.22	1.27
	58.9	60.0	62.0	60.0	65.0	68.0	70.0	65.0	80.0

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Use

The 17.34 acres owned per farm in Category II (transi-
l) was the highest average acreage reported in the study
e 3.3). The Volta region reported the smallest acres
d. By definition, own land implies the farmer operated
mily land over which he had a usufuctuary or possessory
[Ollenu, 1971]. As the table indicates, with the
tion of the Volta region, a sizeable portion of the
cultivated acreage is rented. What this implies is
given the opportunity in terms of the availability
re production resources, the farmers may expand the
vated acreage.

Labor Force

The family is the source of the bulk of farm labor
. In terms of man equivalents (M.E.) the average size
:m family in the study areas ranged from 5.028 (for
)ry II representative farm in the Brong-Ahafo region)
.ow figure of 2.4 for Category II farm in the Central
ı. The differences between the areas emerge further
.abor use was compared on the basis of M.E. per crop
There were consistent differences between Category
Category II representative farms when using this
f comparison. In all the areas, also, the comparison
n the basis of "cultivated acre" per M.E. shows that
ry II farms used more labor force.

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ual Labor

Additional to family labor available on the farm, some ual labor was needed periodically to supplement the manent family labor force (Table 3.3). The amount of ual labor in man-days recorded in the areas was a reflec- n on the cropping pattern predominant in a given area. In study areas in Ashanti and Brong-Ahafo regions where yam the most important crop, the busy seasons during which or demand increased were land clearing, land preparation king yam mounds) and harvesting.[3] In the remaining as where cassava was next in importance to maize, land aring and cultivation were the periods during which time or demand peaked.

n Capital

Capital appeared to be the most limiting resource in study areas. Two main sources of capital were observed: ings and noninstitutional credit. In the aggregate, ating capital was the highest for the Category II esentative farm in the study area in Brong-Ahafo. It least in the Volta region (Table 3.3). However, on per basis, Category II farms in the Eastern region reported highest figure.

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[3]Despite the frequent occurence of maize in mixtures other crops in these areas, maize was a "secondary" in terms of its contribution to the gross income.

ropping Pattern

Table 3.3 summarizes the main crops and the different rop-mixtures recorded during the survey. Acreages for ach type of crop mixture are also shown by technological ategories (Table 3.4). Maize was the only crop that was rown in a sole stand.

Mixed-cropping is a type of horizontal or lateral crop iversification. Two fundamental factors--physical and ocio-economic considerations--interact to determine the ypes of crops and mixtures found. Among the physical actors are rainfall, vegetation, soil, temperature. These nteract with socio-economic factors--tradition, food eating abits, accessibility (geographic), land-labor availability nd relative prices.

In the survey, open-ended questions were put to the armers to ascertain the reasons for practicing mixed-ropping. The answers were coded in binary units (Table 3.5). n addition to the reason of security which was assumed way during the questioning, the reasons of tradition were onsistent in Ashanti, Brong-Ahafo, Volta and Eastern egions for the major season cropping. The Central region eported shortage of labor as the major reason. For the inor season cropping, farmers expressed the need, in ddition to security factors, to maximize returns on imiting factors--land and labor.

Table 3.4. Average Acreage of Different Crop Enterprises by Techological Categories by Region.

Enterprise	Region								
	Ashanti		Brong-Ahafo		Central		Eastern		Volta
	Trad*	Improved**	Trad	Improved	Trad	Improved	Trad	Improved	Trad
	Acres								
M	6.0	5.86	7.9	8.6	2.75	3.7	2.96	5.32	1.13
MC	4.5	9.19			6.62		1.28		.63
MP			4.6						
MY		2.46		38.3					
MV	6.7	7.35			3.63				
MCP			1.02		1.51		5.16		3.84
MCO	.69		4.55		1.25		3.11	2.1	1.34
MCY	5.08	3.38	4.47	60.08	3.85	1.5	1.13		1.34
MCV			3.4		3.68	1.69	1.28	4.32	.55
MPO			1.06						
MPY	20.7								
MOV			0.46						
MYV	6.21		7.57						
MCPO	3.6	1.46	1.11	3.45	1.08		.98		.91
MCPY	1.25				1.12			3.6	.53
MCPV	1.16		11.14		1.82	.85	2.24		.45
MCOY	6.6		6.02				1.88	1.46	1.2
MCOV		2.4		11.19	2.55		3.4	3.83	
MCYV	4.64	3.51			5.25		10.13		.56
MPOY									
MPOV	1.0	1.87	4.13						
MPYV			3.81	8.13					
MCPOY	1.6		6.25		8.5		1.56	2.08	.79
MCPOV	1.28	1.0	14.73	8.86	7.34	4.5	4.13		.74
MCPYV			7.61	11.31			.91	4.71	.98
MCOYV	1.22		3.76						.42
MPOYV	9.0	7.79	2.34		3.5				
MCPOYV	1.12		16.63		.75			4.6	.39 (16)

*Trad = Traditional or Category 1 Farms.
**Improved = Transitional or Category 2 Farms.

Key:

M = Maize
C = Cassava
P = Plantain
O = Cocoyam
Y = Yam
V = Vegetable

Source: Compiled from survey data.

... Mix-Cropping as Given by the Farmers: Number of Farmers Responding to Specific Questions.

Reason	Region									
	Central		Volta		Eastern		Ashanti		Brong-Ahafo	
	Major Season	Minor Season	Major Season	Minor Season	Major Season	Minor Season	Major Season	Minor Season	Major Season	Minor Season
Follow tradition	30	27	35	28	30	30	49	37	37	14
Higher output	20	16	27	23	30	22	43	28	35	19
Shortage of land	8	9	42	41	37	22	5	4	32	26
Greater use of labor	43	39	13	12	12	6	36	34	8	28
More certain of yield	15	14	13	32	14	8	31	18	16	24
Optimum land utilization	16	19	14	18	10	8	16	27	10	21
Initate neighbors	6	5	16	18	2	12	7	22	3	24
Legumes (increase fertilizer)	2	1	8	9	4	4	16	7	19	17

Source: Compiled from survey data.

op Yields

The average yields of crops are depressed when grown mixtures rather than grown in pure stands. Reason often ted for the depressed yield are: 1) lower plant density individual crops and 2) competition for nutrients, space d light [Norman, 1973]. However, the depressed yields of dividual crops are overcompensated by the aggregate yield r acre of all the crops.

"Sample plot yield" estimation procedure was employed derive the crop yields. There were considerable yield fferences between the two technological categories of presentative farms. Category II farms which benefited om fertilizers and superior planting materials and cultural actices produced higher crop yields. With the exception maize, the economic rate of fertilizer application for e crops had not been established for the country. Crop eld responses for the Category II representative farms refore varied from locality to locality because of the ferent levels of fertilizer applications used.

Concluding Remarks

Two types of representative farms--indigenous or ditional and transitional farms--were identified for the y. Throughout the study, those farms will be referred s Category I and Category II farms, respectively.

Several variables such as the age of the holder, his acy level, size of farm labor force, net worth size lding as indexed by acreage cultivated, are important

en defining a representative farm. But, in general, the gor employed in defining a representative farm depends on the purpose of a particular study [Ogunforowa, 1972]. cording to Ogunforowa, if the objective of the study is t the derivation of aggregate supply functions, but rather identify the direction of farm adjustment or expansion th and/or to estimate responses to varying resource and ice levels in an area, a less rigorous method of bench-rk farm construction may be used. Such was the purpose this study.

Despite the usefulness of representative farm approach permitting limited statistical aggregation, and opera-onal flexibility, there are potential problems of aggre-tion associated with its use. Specifically, sampling ror, specification error and stratification error may mit the usefulness of the representative farms in predic-ng farm adjustment [Heady, 1961; Day, 1963; Lee, 1966; ler, 1961; Lard, 1963]. Although no attempt was made to imate the size of these errors in this study, attempts e made through two-stage probability sampling and careful atification procedures to minimize the likely impact of se errors.

CHAPTER IV

THE STRUCTURE OF THE LP MODELS FOR THE STUDY

Introduction

This study uses three interrelated phases to discuss e problems associated with optimum resource organization subsistence smallholder farming in Ghana. The empirical alysis takes place in Phases I to III.

1. The static linear programming phase: this phase focuses on the determination of what the representative farmers are doing. It deals with land, labor, initial operating capital (cash available), consumption levels and borrowing as fixed. It includes activities for mixed-cropping, labor (hiring and selling), sales, purchases, credit and land clearing.
2. The poly-period linear programming phase: this phase allows cash flows, varying farm size and associated assets with no restirction put on the amount of credit the farmers could obtain, interdependence of production--consumption and investment, and on-farm storage of farm products with due allowance made for storage losses or attrition. It is an expanded version of the Phase I model.

3. New technology phase: in addition to the historical mixed-cropping enterprises embodied in the first two phases, this phase incorporates continuous cropping (in pure-stands) of the six crops, viz. maize, cassava, plantain, cocoyam, yam and pepper. These enter the model as alternative cropping activities. Alternative technologies of producing these crops also feature in the model. The technological coefficients for the various cropping activities were derived from experimental data [Hudson, 1972]. This model expands the Phase II model to include alternative technologies of producing these crops.

The policy analysis simulates several policy outcomes ed on varying resources and activity levels for Phases I II models. The linear programming models for the repre- tative farms for the first three phases are discussed the subsequent sections of this chapter. Under three dings: 1) the objective function, 2) the constraint ucture and, 3) the activity set. A theoretical presenta- of these will be given first to be followed by the vant empirical presentation.

Phase I--The Intra-Firm Linear Programming Model

The Objective Function

The linear objective function used in the study can efined as:

$$\text{Max}\pi = \sum_{j=1}^{v} (Z_j^s S_j^*) + \Sigma_\gamma Z_\gamma^L L_\gamma - \sum_{j=1}^{u} Z_j^P P_j - \sum_{j=1}^{k} Z_j^I I_j$$

$$- \Sigma_\gamma Z^H H_\gamma - \sum_{j=1}^{v} C_j S_j^f$$

subject to land, capital, labor and miscellaneous constraints,

where:

π = Net returns (profits) to fixed inputs.

C_j = Average buying price of the jth commodity.

S_j^f = Actual level of jth food buying activity.

Z_j^s = Average selling price of jth output.

S_j^* = Actual level of jth selling activity.

Z_γ^L = Opportunity cost of family labor per period γ

L_γ = Actual level of family labor hired out in hours per period γ.

Z_j^P = Per unit cash cost of jth variable input.

P_j = Actual level of jth variable input purchasing activity.

Z_j^I = The current cost of the jth quasi-fixed input computed by the payback principle: i.e., for the jth investment

$$Z_j^I = \frac{(1 + a)^T}{T} C_j$$

where T is the useable life, a, the rate of interest on loans to farmers by the banks, C_j is the acquisition cost.

I_j = The level of the jth quasi-fixed input.

Z_γ^H = Cost per hour of hired labor during period γ.

H_γ = Actual amount of hired labor in hours in period γ.

Maximization of net farm income subject to the satis-
ction of household food consumption requirements is the
erational goal of the farmers used in the model. It is
"constrained" type of profit maximization [Day, 1962]. In
bsistence farming of the type covered in this study, the
ovision of food for the members of the farm household
generally given top priority. Norman [1972] refers to
is type of goal seeking as security and profit maximization.

The Activity Set

The activity set facing the representative farm is
noted by:

$$1,\ldots,P_u,\ O_{u+1},\ldots,O_k,\ H_I,\ldots,H_\gamma,\ L_I,\ldots,L_\gamma,$$

$$I,\ldots,V_\gamma,\ Q_I^m,\ldots,Q_m^m,\ Q_{m+1}^{-m},\ldots,Q_p^{-m},\ C_I,\ldots,C_g$$

$$I,\ldots,S_g,\ F_I,\ldots,F_f,\ \bar{L}_m,\ \bar{L}_N,\ B\}$$

ere:

$,\ldots,P_u$ = Activities involving the purchase of the variable inputs.

$-1,\ldots,O_k$ = Activities involving the purchase of quasi-fixed inputs.

$\ldots,H_\gamma$ = Activities to allocate hired labor to γ farm operations or periods.

$\ldots,L_\gamma$ = Activities to sell family labor in γ period.

$\ldots,V_\gamma$ = Activities to allocate overhead labor in γ periods.

$\ldots,Q_m^m$ = Production activities involving pure-stand cropping in major season.

$1,\ldots,Q_p^{-m}$ = Production activities involving mixed cropping in major season.

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$C_1, \ldots, C_g$ = Activities involving household consumption of subsistence crops.

$S_1, \ldots, S_V$ = Activities involving the sale of V outputs for cash.

$F_1, \ldots, F_f$ = Activities involving the purchase of f outputs for domestic consumption.

M = Activity associated with additional land clearing in major season.[1]

N = Activity associated with additional land clearing in minor season.

N = Production of maize in the minor period.

= The activity associated with the farm-firm's net borrowings.

It is assumed in the study that the representative farm each of the five regions is engaged in 1) production tivities; 2) input purchasing activities (both variable d quasi-fixed input); 3) labor activities (hiring, selling d overhead); 4) financial activities; 5) land activities; food purchasing activities; 7) consumption activities; 8) supply of storage activities. The relevance and pe of these activities are discussed in detail in the tions that follow, using one region as an illustration.

In addition, the following assumptions were made for model in this study: 1) input-output coefficients in- ed are consistent with the farmer's cultural practices available technologies;[2] 2) the government input subsidy

[1]This refers to land additional to the piece of land med already cleared for farming in the current season.

[2]The Phase III, however, the technological coefficients in the LP matrix were derived from recommended practices ; improved technology of production.

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nd output expansion programs will remain in essentially
heir pre-1972 coup forms; 3) the problem of inflation
ollowing the 1971 devaluation of the currency is not
nsidered; 4) the land tenure system in the study areas
flexible enough to effect acreage expansion without
fficulty; 5) the current methods of financing the farmers
the Agricultural Development Bank and the commercial
nks will continue.

Phase I of the model is stirctly concerned with static
near programming allocation. Category I and Category II
presentative farms are considered representing traditional
d transitional farms, respectively. The submatrices for
e Brong-Ahafo region are presented in Tables 4.1 to 4.7.
e structures are the same for all the regions, so they
e not repeated here.

p Activities

The crop and crop transaction activities included in
Category II in Brong-Ahafo region, used as an example,
maize, cassava, plantains, cocoyams, yams and vegetables
per). They enter the model in the various mixed-crop
rprises. Maize is the only crop in pure-stand and is
only minor season crop (MZN) (Table 4.1). In all the
es, a negative sign in front of a coefficient indicates
ng to the resource and positive signs indicates using
resource.

Table 4.1. Crop Activities for Phase I Category II, Brong-Ahafo Region.

	Objective														
01	Major season land	Acre	LANDMJ	0	0	0	0	0	0	0	0	0	0		
02	Minor season land	Acre	LANDMN	1	1	1	1	1	1	1	1	1	1		
03	Labor period 1	Hour	LABRP1	0	0	0	0	0	0	0	0	1	1	<	17.34
04	Labor period 2	Hour	LABRP2	83	83	83	83	83	83	83	83	0	1	<	5.77
05	Labor period 3	Hour	LABRP3	113	107	223	94	167	75	94	358	0	0	<	1086
06	Labor period 4	Hour	LABRP4	45	30	194	258	223	248	258	295	0	0	<	551
07	Labor period 5	Hour	LABRP5	0	25	30	30	94	94	94	90	0	0	<	1641
08	Labor period 6	Hour	LABRP6	0	63	50	75	50	80	80	60	47	0	<	518
09	Labor period 7	Hour	LABRP7	0		60	60	125	100	90	90	125	0	<	527
10	Annual labor	Hour	LABRAN	274	528	70	135		70	135	135	67	0	<	1048
11	Buy seed-maize	Lb	MZP	15	15	710	735	742	750	834	1111	239	0	<	999
12	Buy cassava	100 units	CASP	0	0	1.71	1.26	0	1.8	1.26	1.21	0	=		6370
13	Buy plantain	single	PLAP	0	0	0	200	0	0	2	1.8	0	=		0
14	Buy cocoyam	100 units	COYP	0	0	0	1.8	2	2.2	1.8	0	0	=		0
15	Buy yam	100 units	YAMP	0	3	2.5	0	2.7	0	0	2.0	0	=		0
16	Buy vegetable	Lb	VERTP	0	0	0	0	2.0	2.0	2.0	1.8	0	=		0
17	Buy chissel	Unit	CHIP	1	1	1	1	1	1	1	1	1	=		0
18	Buy basket	Unit	BASKP	4	6	8	10	10	10	10	12	4	=		0
19	Buy matchet	Unit	MATP	2	2	2	2	2	2	2	2	2	=		0
20	Buy hoe	Unit	HOEP	2	2	2	2	2	2	2	2	2	=		0
21	Buy axe	Unit	AXEP	1	1	1	1	1	1	1	1	1	=		0
22	Output maize (D)	220 lbs	MZOP4	-7.5	-6.25	-6.36	-5.55	-5.35	-5.16	-5.41	-5.12	-6.4	=		0
23	Output maize (V)	220 lbs	MZVP4	- .75	- .625	- .64	- .54	- .52	- .54	- .512	- .512	- .64	=		0
24	Output cassava	200 lbs	CASP7	0	0	-22.5	-19.8	0	-18.3	-14.24	-12.1	0	=		0
25	Output plantain	lbs	PLAP7	0	0	0	-2500	0	0	-180	-190	0	=		0
26	Output cocoyam	Bunch 120 lbs	COYP6	0	0	0	-23.5	-19.48	-19.5	-19.4	0	0	=		0
27	Output yam	100 tub	YAMP6	0	-14.6	-13.6	0	-12.85	0	0	-12.0	0	=		0
28	Output vegetable	Lbs	VEGP4	0	0	0	0	-316.4	-302	-337.6	0	0	=		0
29	Buy fertilizer	Bag	FERTP	2	3	3	4	4	4	4	4.5	2	=		0

Source: Computed from survey data.

Table 4.2. Input Purchasing Activities: Category II Farms Brong-Ahafo Region.

Row No.	Variable Names	Unit	Row Name	maize PMZ	cassava PCAS	plantains PPLA	cocoyams PCOY	yams PYAM	vegetables PVEG	fertilizer PFERTP	matp. PMAT	hoe PHOE	bask. PBASK	axe PAXE	chass. PCHI	RHS
1	objective function	¢	¢BJ	-.06	-2.5	-.06	-3.0	-5.0	-5.0	-2.8	-.84	-.39	-.3	-.79	-.32	
2	buy seed maize	16	MZP	-1												= 0
3	buy cassava	100	CASP		-1											= 0
4	buy plantain	singh	PLAP			-1										= 0
5.	buy cocoyams	100	COYP				-1									= 0
6	buy yams	100	YAMP					-1								= 0
7	buy vegetables	lb	VEGP						-1							= 0
8	buy fertilizer	bag	FERTP							-1						= 0
9	buy baskets	unit	BASKP										-1			= 0
10	buy chissels	unit	CHIP												-1	= 0
11	buy matchets	unit	MATP								-1					= 0
12	buy hoes	unit	HOEP									-1				= 0
13	buy axes	unit	AXEP											-1		= 0
14	operating capital	¢	CASH	.06	2.5	.06	3.0	5.0	.5	2.8	.84	.39	.3	.79	.32	≤250

Source: Computed from survey data.

Table 4.3. Labor Activities: Category II, Brong-Ahafo.

Row			Row	SLAB	SLAB	SLAB	SLAB	SLAB	SLAB	SLAB	HLAB	HLAB	HLAB	HLAB	HLAB	HLAB	HLAB	LBR	LBR	LBR	LBR	LBR	LBR	LBR	RHS

	Unit	Name	R1	R2	R3	R4	R5	R6	R7	HLAB R1	HLAB R2	HLAB R3	HLAB R4	HLAB R5	HLAB R6	HLAB R7	LBR N1	LBR N2	LBR N3	LBR N4	LBR N5	LBR N6	LBR N7	RHS
objective function	¢		.48	.48	.48	.48	.48	.48	.48	-.7	-.6	-.65	-.6	-.65	-.55	-.55	0	0	0	0	0	0	0	
labor period 1	hrs.	LABRP1	1							-.66							1							≤ 1086
labor period 2	"	LABRP2		1							-.66							1						≤ 551
labor period 3	"	LABRP3			1							-.66							1					≤ 1641
labor period 4	"	LABRP4				1							-.66							1				≤ 518
labor period 5	"	LABRP5					1							-.66							1			≤ 527
labor period 6	"	LABRP6						1							-.66							1		≤ 1048
labor period 7	"	LABRP7							1							-.66							1	≤ 999
annual	"	LABRAN	1	1	1	1	1	1	1	-.66	-.66	-.66	-.66	-.66	-.66	-.66	1	1	1	1	1	1	1	≤ 6370
labor off f P1	"	LABROF1	1																					≤ 258
labor off f P2	"	LABROF2		1																				≤ 129
labor off f P3	"	LABROF3			1																			≤ 397
labor off f P4	"	LABROF4				1																		≤ 129
labor off f P5	"	LABROF5					1																	≤ 129
labor off f P6	"	LABROF6						1																≤ 258
labor off f P7	"	LABROF7							1															≤ 258
annual	"	LABROFAN	1	1	1	1	1	1	1															≤ 1555
Overhead Labor																								
period 1	"	LABROH1															1							= 167
period 2	"	LABROH2																1						= 83
period 3	"	LABROH3																	1					= 250
period 4	"	LABROH4																		1				= 83
period 5	"	LABROH5																			1			= 83
period 6	"	LABROH6																				1		= 167
period 7	"	LABROH7																					1	= 167
annual	"	LABROHAN															1	1	1	1	1	1	1	= 1001
operating	¢	CASH								.70	.60	.65	.60	.65	.55	.55								≤ 250

Source: Computed from survey data.

Table 4.4. Food Buying, Consumption and Sales Activities: Category II Farms Brong-Ahafo Region.

Row No.	Column Name	Unit	Row Name	Consumption							Selling						Buying				RHS
				CONS	CONSV	COCAS	COPLA	COCOY	COYAM	COVEG	SNZD	SNZV	SCAS	SPLA	SCOY	SYAM	SVEG	BNZ	BCAS	BPLA	BCOY	BYAM	BVEG	

No.	Name		Name	Consumption							Selling								Buying							RHS
				COMZ	COMZV	COCAS	COPLA	COCOY	COYAM	COVEG	SMZD	SMZV	SCAS	SPLA	SCOY	SYAM	SVEG	BMZ	BCAS	BPLA	BCOY	BYAM	BVEG	
01	Objective Function	≠		0	0	0	0	0	0	0	8.5	9.5	3.5	.65	5.7	32.0	.10	9.5	5.0	.75	6.9	33.0	.12	
02	Maize output (O)	220 lbs	MZOP	1							1							-1						= 0
03	Maize output (V)	220 lbs	MZVOP		1							1												= 0
04	Cassava output	220 lbs	CASOP			1							1						1					= 0
05	Plantain output	Bunch	PLAVP				1							1						-1				= 0
06	Cocoyam output	120 lbs	COYOP					1							1						-1			= 0
07	Yam output	100 unit	YAMOP						1							1						-1		= 0
08	Vegetable output	Lbs	VEGOP							1							1						1	= 0
Consumption																								
09	Maize (dry)	220 lbs	CMA	1																				≥ .8231
10	Maize (veg)	220 lbs	CMAV		1																			≥ .08
11	Cassava	120 lbs	CCAS			1																		≥ 3.03
12	Plantain	Bunch	CPLA				1																	≥40.52
13	Cocoyam	120 lbs	CCOY					1																≥ 4.33
14	Yam	100 Lbs	CYAM						1															≥ .943
15	Vegetable	Lbs	CVEG							1														≥60.0

Source: Computed from survey data.

Row No.	Column Names	Unit	Row Name	CLADM	CLADN	BORRW	FMZ	PCAS	PPLA	PCOY	PYAM	PVEG	PFERT	PMAT	PHDE	PBASK	PAXE	PCHI	HLA BR1	HLA BR2	HLA BR3	HLA BR4	HLA BR5	HLA BR6	HLA BR7	RHS
1	objective function	¢		-23.8	-11.9	-.06	-.06	-2.5	-.06	-3.0	-5.0	-.5	-2.8	-.84	-.39	-.3	-.79	-.32	-.7	-.6	-.65	-6	-.65	-.55	-.55	
2	major season land	acre	LANDM1	-1																						
3	minor season land	acre	LANDN1		-1																					≤17.34
4	unused land-major	acre	LANDM2	1																						≤ 5.77
5	unused land-minor	acre	LANDN2		1																					≤15.0
6	operating capital	¢	CASH	23.8	11.9	-1	.06	2.5	.06	3.0	5.0	.5	2.8	.84	.39	.3	.79	.32	.7	.6	.65	.6	.65	.55	.55	≤ 4.0
7	borrowed cash	¢	BORROW			1																				≤250
																										≤46.65

Source: Computed from survey data.

Table 4.7. Additional Activities and Constraints.

Row No.	Column Name	Unit	Row Name	CUSTHM	CUSTHN	BWEED	MAZA2	MAZA3	. . . . .	VEGA1	VEGA2	MAZAM2*	MZAN3*	RHS
1	Custom hire (M)	Hrs	Custom HM	-1			1	1	. . . . .	1	1			= 0
2	Custom hire (N)	Hrs	Custom HN		-1		1	1	. . . . .	1	1	1	1	= 0
3	Buy Weedicide	Bag	WEEDIP			-1	-	2	. . . . .	-	2	-	2	= 0

*MAZAM2 and MZAN3 mean minor season maize produced by the two alternative technologies.

Source: Computed from survey data.

No.														
1	Custom hire (M)	Hrs	Custom HM	-1			1	1	. . . . .	1	1			= 0
2	Custom hire (N)	Hrs	Custom HN		-1		1	1	. . . . .	1	1	1	1	= 0
3	Buy Weedicide	Bag	WEEDIP			-1	-	2	. . . . .	-	2	-	2	= 0

*MAZAM2 and MZAN3 mean minor season maize produced by the two alternative technologies.

Source: Computed from survey data.

Table 4.7. Additional Activities and Constraints.

Row No.	Column Name	Unit	Row Name	CUSTHM	CUSTHN	BWEED	MAZA2	MAZA3	. . . . .	VEGA1	VEGA2	MAZAM2*	MZAN3*	RHS
1	Custom hire (M)	Hrs	Custom HM	-1			1	1	. . . . .	1	1			= 0
2	Custom hire (N)	Hrs	Custom HN		-1		1	1	. . . . .	1	1	1	1	= 0
3	Buy Weedicide	Bag	WEEDIP			-1	-	2	. . . . .	-	2	-	2	= 0

*MAZAM2 and MZAN3 mean minor season maize produced by the two alternative technologies.

Source: Computed from survey data.

As shown in Table 4.1 major season land is restricted
17.34 acres and the minor season land is in turn restric-
to 5.77 acres. In the output balance restriction, two
es of maize output are identified: MZOP4 and MZVOP4,
ely dry maize and maize (green) used as vegetable,
pectively.

hasing Activities

There are two categories of the purchae activities:
he purchase of variable agricultural inpust such as
s and planting materials. Included in this category
maize (PMZ), cassava sticks (PCAS), plantain suckers
A), cocoyam tubers (PCOY), yam seedling (PYAM) vegetable
(PVEG) and fertilizer (FERT). These are variable
rs of production and the amount required varies with
evels of each production activity (Table 4.2).
In general, the decision to purchase variable inputs
as seed or planting materials depends upon whether or
omestically owned substitutes can be obtained. If the
inputs were to have zero opportunity cost, as it is
case of family labor, there would be no need to pro-
hose inputs at a cost. In that case, the planting
als will not be purchased until the quantity of the
substitute is exhausted. But, in an attempt to account
for the cost of production, some imputed value of those
is required. Hence, their inclusion in the model
ctivity.

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The second group considered in the model includes the
rchase of quasi-fixed factors of production. They are
led quasi-fixed inputs to distinguish them from fixed
uts which do not vary with the levels of activity. Included
the quasi-fixed capital are matchetes, hoes, axes and
sels. They have associated with them a cost computed on
ayback principle and a flow of service through time.
ir objective values are, therefore, discounted, based
their expected life, to reflect this phenomenon.

The input purchasing activity has negative coefficient
he row column indicating that an increase of one unit of
inputs in the basis will increase the stock (assumed
ially at zero levels) of these inputs. They also con-
cash (operating capital) hence, the positive coefficient
he coefficients in the cash row.

r Activities (Table 4.3)

The labor activities provide for the selling and hiring
easonal labor by periods of the year. The labor hiring
vities (HLABR1 to HLABR7) have a negative coefficient
ie row column of labor supplied by the family by periods
RP1 to LABRP7). The sign indicates that an increase of
nit of HLABR in the basis will increase the stock of
labor hours by .66 unit.[3] Hence, HLABR relaxes the

[3]The discount is meant to reflect the effective hours
lly put into work by the hired labor, i.e., after dis-
ing for hours spent in walking to the field and lunch
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or constraint. The wage rate of HLABR is positive in the
flow meaning that an increase of one unit of HLABR
ces the cash available by one unit, which equals the
esponding wage rate period in a particular period.
, the extent to which the HLABR relaxes the labor
traint depends upon the stock of cash available to
farmer.

Labor selling activities (SLABR1 to SLABR7) draw from
available stock of family labor hours for farm work
RP1 to LABRP7) and the stock of available family hours
off-farm work (LABROF1 to LABROF7). The coefficient in
respective row columns are positive indicating the sale
e unit of labor (SLABR) reduces the ith LABRP or LABROF
raint by one unit.

The sale of family labor is priced using the oppor-
y cost principle. The source of the shadow prices
as the objective value for labor selling activities
e model is from the work of Stern and Roemer [May, 1972]
is based on Rouke's study: "Wages and Incomes of
ultural Workers in Ghana," [Rouke, 1971]. These two
s supply the most up-to-date reliable estimates of
wage rates for farm labor in Ghana (Table 4.3).
The balance equations--depicting equality signs in the
the overhead labor rows (LABROH)--indicate that these

levels of LABROH draw from the stock of family on-farm labor hours. They have zero net revenue (Table 4.3).[4]

Food Buying, Consumption and Sales Activities (Table 4.4)

Food buying activities simply replenish the stock of available output from which consumption requirements are drawn. They have negative coefficients implying that one unit of the buying activity increases the corresponding row column by one unit. Because of the subsistence nature of farming and, especially, in a static LP framework, it is expected that once the decision to produce is taken, food requirements will be met first before any selling eventuates.

Sales Activities

The sales activities considered in the model are:

SMD = Sale of dry maize

SMZV = Sale of "green" maize

SCAS = Sale of cassava

SPLA - Sale of plantain

SCOY = Sale of cocoyam

SYAM = Sale of yam

SVEG = Sale of vegetables

Two assumptions are required here: 1) that the

[4]The overhead labor (LABROH) was composed of: 1) hours used in walking to and from the land from place residence; and 2) labor used in maintaining bush fallow cluding the continuous harvesting of bush fallow crops the performance of other tasks such as the gathering of ewood to be used at home as fuel and hunting for game crabs.

cropping pattern has no effect on the characteristics of the product. This assumption is necessary to ensure some homogeneity in the output irrespective of the cropping enterprise that enter the final plan, and 2) sales take place in a nearby rural competitive market.

The marketed surplus is a residual of two decision processes: What to produce and how much of it on one hand; and how much of it to withdraw for consumption purposes. Symbolically, letting Q_j represent the output of the commodity; S_j, the sale of the jth commodity and C_j the exogenously determined consumption of the jth commodity, the sales or the marketed surplus function can be represented by the following equations--six equations, one for each jth crop.

$$S_j = Q_j - \tilde{C}_j \qquad j = 1,. \ . \ .,6$$

Obviously if $\tilde{C}_j = 0$, $S_j = Q_j$ and so long as $\tilde{C}_j \leq Q_j$, $S_j \geq 0$. Graphically, this can be shown as:

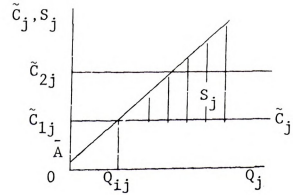

Figure 4.1. Marketed surplus.

The total supply of the jth commodity in the country is the sum of the marketed surplus of the jth commodity (i.e., $\sum_{j=1}^{n} S_j$).

Home consumption needs act as a constraint upon the sale of output. When the objective of production is to produce with a view to securing food for household consumption, almost all the product is consumed and accordingly there is little or no marketed surplus. We can define a marketing ratio as the proportion of cash receipts through marketing to value of output of farm products. The ratio can be shown as:

$$B_j = \frac{S_j}{Q_j} = \frac{\text{Sales of product}}{\text{Total value product of jth product}}$$

As the production for sale becomes more predominant, and at the same time the production for consumption weakens, the bigger the value of B_j. The marketing ratio is thus an indication of the commercial orientation of the farmers.

Table 4.8a to Table 4.8e portray the marketing ratios the sample holdings in the study areas with respect to size--the dominant crop.

The data support the hypothesis that when the size of farm operation as measured by acreage becomes larger, its rketing ratio increases. In the Eastern and Volta regions, rms belonging to all the acreage cohorts show high commercial orientation. In the Central, Ashanti and Brong-Ahafo gions, farms of less than two acres can be presumed to be oducing mainly for home consumption.

Table 4.8a. Marketing Ratios of Sample Maize Holdings in the Eastern Region.

FARM SIZE	TOTAL ACREAGE	NO. OF HOLDINGS	OUTPUT (BAGS)	SALES (BAGS)	CONSUMPTION (BAGS)	RATIO
0.1 - 0.99	7.50	11	42.0	26.05	15.95	.6210
1.0 - 1.99	35.40	26	134.30	84.38	49.92	.6357
2.0 - 2.99	19.57	8	75.50	49.95	25.55	.6616
3.0 - 3.99	21.14	6	40.00	28.40	11.60	.7100
4.0 - 4.99	17.43	4	31.50	23.55	7.95	.7424
5.0 - 5.99	21.70	4	62.0	49.90	12.10	.8030
6.0 - 6.99	18.94	3	30.0	26.80	3.20	.8933
Over 6.99	27.69	2	82.00	77.50	4.50	.9451

Source: Compiled from Survey Data.

Table 4.8b. Marketing Ratios of Sample Maize Holdings in the Central Region.

FARM SIZE	TOTAL ACREAGE	NO. OF HOLDINGS	OUTPUT (BAGS)	SALES (BAGS)	CONSUMPTION (BAGS)	RATIO
0.1 - 0.99	10.82	18	32.55	7.8	24.75	.2396
1.0 - 1.99	17.74	13	49.1	19.77	29.33	.4025
2.0 - 2.99	22.0	10	52.5	28.53	23.97	.5433
3.0 - 3.99	12.54	4	27.25	15.28	11.97	.5606
4.0 - 4.99	21.60	5	80.0	46.7	33.3	.5838
5.0 - 5.99	30.5	6	113.0	95.35	17.65	.8438
6.0 - 6.99	60.0	2	26.0	22.7	3.3	.8731
7.0 - 7.99	21.5	3	50.0	46.75	3.25	.933
8.0 - 8.99	16.5	2	66.0	63.0	3.0	.9545
Over 8.99	45.0	3	143.0	139.9	3.1	.9783

Source: Compiled from Survey Data.

Table 4.8c. Marketing Ratio fro Maize, Volta Region (Region 2).

FARM SIZE	TOTAL ACREAGE	NO. OF HOLDINGS	OUTPUT (BAGS)	SALES (BAGS)	CONSUMPTION (BAGS)	RATIO
.1 - .9	9.0	22	37.08	17.56	19.52	.4700
1.0 - 1.9	14.6	11	30.5	18.45	12.05	.605
2.0 - 2.99	4.86	2	8.5	6.56	1.94	.765
3.0 - 3.99	3.12	1	6.5	5.33	1.17	.820

Source: Compiled from Survey Data

Table 4.8d. Marketing Ratios for Maize, Sample Maize Holdings: Brong-Ahafo Region.

FARM SIZE	TOTAL ACREAGE	NO. OF HOLDINGS	OUTPUT (BAGS)	SALES (BAGS)	CONSUMPTION (BAGS)	RATIO
.1 - .99	1.25	2	3	.8	2.2	.2666
1.0 - 1.99	18.24	12	51.5	31.24	20.25	.6066
2.0 - 2.99	8.39	3	24	16.12	7.88	.6716
3.0 - 3.99	17.56	5	47	34.85	12.15	.7419
4.0 - 4.99	8.89	2	21	16.31	4.69	.7767
5.0 - 5.99	16.2	3	48	41.6	6.4	.8666
6.0 - 6.99	19.53	3	40	35.5	4.5	.8875
7.0 - 7.99	15.91	2	58	54.3	3.7	.9362
8.0 - 8.99	33.91	4	94	90.6	3.4	.9638
over 8.99	176.9	10	474	460.75	13.25	.9721

Source: Compiled from Survey Data

Table 4.8e. Marketing Ratios for Maize: Sample Maize Holdings: Ashanti Region.

FARM SIZE	TOTAL ACREAGE	NO. OF HOLDINGS	OUTPUT (BAGS)	SALES (BAGS)	CONSUMPTION (BAGS)	RATIO
.1 - .99	7.42	12	29.2	9.548	19.65	.327
1.0 - 1.99	15.3	9	75	30.7	44.3	.4093
2.0 - 2.99	21.68	9	78.5	46.23	32.27	.5889
3.0 - 3.99	9.75	3	39.0	25.03	13.97	.6418
4.0 - 4.99	25.25	6	99.0	83.63	15.37	.8447
5.0 - 5.99	22.5	4	80.0	68.48	11.32	.856
6.0 - 6.99	19.88	3	48.0	44.56	6.44	.8658
7.0 - 7.99	7.90	1	30.0	27.0	3.0	.9000
8.0 - 8.99	16.5	2	52.0	48.36	3.64	.9300
9.0 - 9.99 and over	68.01	6	211.0	202.08	8.92	.9577

Source: Compiled from Survey Data

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The decision to withold part of the output for home consumption generates some micro-economic interactions worth noticing. The consumption needs reduce the sale of the subsistence crop and probably, the production of nonsubsistence crops.[5] This behavior in turn reduces cash incomes and puts low-income farmers at the mercy of predatory money lenders.[6] Reduced cash incomes may in turn limit the acreage that can be cultivated and the inputs that can be purchased. Accordingly, the ability of the farmers to generate working capital to facilitate the purchase of new variable inputs as well as to generate a stream of savings to be invested in new

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[5]Alternative to the crops covered in the study are rice, tomatoes, pineapples, tobacco, shallots, onions, etc. These crops may prove profitable to raise, but stereotyped consumption behavior on the part of the farmers may preclude their consideration as alternative production possibilities.

[6]The expression here reflects the difference between the cost of short-term borrowing from an institutional source such as from the Agricultural Development Bank which charges an interest of 6.0 percent per annum and the cost of borrowing from local money-lenders whose interest charges may range from 50 percent to 200 percent.

Superficially, the interest charged by the money lenders appear exorbitant as compared with the alternative source. However, when the money lenders give out loans, they consider the risk aspect (i.e., a debtor reneging in loan repayment) and the transaction cost involved in chasing the debtors for loan repayment. Hence, the high rate of interest charged by the money lenders. It is conceivable that the traditional money lenders who operate in the farming areas are rational and also take into consideration their subjective evaluation of the productivity of capital in charging interest on loans they grant. As will be explained later in the text, the fact that many of the farmers resorted to noninstitutional sources of loans to finance farm operations, reveals the attractiveness of this type of loan in the study areas.

implements and power sources is severely limited.[7] Phase II of the model will unravel the import of this phenomenon.

In Table 4.4, there are positive coefficients for the consumption activities. The implication is that one unit of the jth commodity to be consumed will have to be withdrawn from the corresponding output in the output row. Purchasing, on the other hand, adds to the stock of the output much in the same way as sales reduce the stock of the output.

Land and Financial Activities (Table 4.5)

The model provides the acreage expansion along the "intensive-extensive" margin, i.e., acreage can be expanded by clearing more unused major season land (CLADM) or minor season land (CLAMDN). It is assumed that there is enough flexibility in land tenure system to permit this adjustment. In Ashanti and Brong-Ahafo regions where land is relatively less restrictive, the unused land (LAMDM1 and LAMDM2) is owned by the farmers whereas in the remaining three regions, there is rented or rentable land near the farm. CLADM activity in the Brong-Ahafo region has a cost of ¢23.8

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[7] This does not preclude the possibility of the farmers generating farm-produced capital through the investment of their own labor. Examples of farm-produced capital observed in the study are: 1) yam sticks which sometimes may have a useful life of two years; 2) simple wooden structures such as platforms or barns for on-farm storage; and 3) the manufacture of handles for hoes and other simple farm implements.

Because of the predominantly shifting cultivation nature of farming in the study areas, yam sticks and storage platforms were assigned a useful life of one production cycle and thus treated as variable intermediate factors of production. Family labor used in creating them was treated as part of farm operation. Handles for hoes were treated as fixed factors and assigned a useful life of two years.

and uses ¢11.9 capital. The signs of the coefficients indicate that one acre of cleared land will relax the corresponding land constraint by one acre.

Land clearing is considered in the model as investment which is costed based on the payback principle, i.e., for the jth cleared land,

$$CLAMD_j = \frac{(1 + a)^T}{T} \cdot C_j$$

where T is the useable life, a, the rate of interest and C_j is the actual cost of clearing the land. The useful life, T, is open to a wide range of interpretation. A useable life of four years was assumed in this model. This conforms with the normal behavior of the farmers, i.e., after cultivating the land for three to four years, it is allowed to revert to fallow for the next six or seven years.

The extent to which CLADM and CLADN activities can relax the land constraint (LAMDM1 and LAMDN1, respectively) is dependent upon the stock of capital available. As the table indicates, the cash constraint (CASH) can also be relaxed by the borrowing activity (BORRW). The cost of capital (interest rate) is the rate at which the institutional banks are allowed to lend money to the small-scale producers. The capital borrowing activity with negative coefficient (-1) in the cash row means that an increase in this activity will increase the stock of capital available to the farmer and thus not only relax the cash constraint,

but help to further relax the input purchase or land clearing constraint.

The Constraint Structure

Agricultural production on the representative farm in Phase I is restricted by 1) the perennial constraints viz. land, farm labor and money capital (cash available), 2) borrowings, 3) the farm-household consumption requirements, 4) miscellaneous constraints such as overhead labor, off-farm labor and non-negativity of activity levels. Each of these constraints used in the model are defined in detail below.

Agricultural Land

Three categories of land are recognized: Major season land, minor season land and unused land. The availability of land serves to limit the acreage of the various crops on a farm and influence cropping patterns. Within a given land type, land is treated as a homogeneous resource and all the crops considered in the model can be grown on the land of the same quality. Stratification of land based on the physical properties would have been more desirable according to Day [1963] and Schaller [1962]. In their respective studies, the region was subdivided into several areas according to the physical characteristics of the soil. In this study, soil differences between regions are, however, recognized. According to Adams [1962] when crops have been

grown by an agricultural community in Ghana for a long period, the farmers accumulate, by experience, considerable knowledge of soils which are suited to any particular crop. Within a region, therefore, the farmers growing the same crops are expected to use soils of similar characteristics.

In the project areas, land can be bought, leased, rented or acquired through clan or communal ownership. The model used in this study assumes such a flexibility in the land tenure system. This assumption is supported by the Ministry of Agricultural Study--"Proposal for a Maize Development Project in Ghana" [Ministry of Agriculture, 1971]. In that study, an observation is made that the tenure arrangements do not present serious obstacles to the introduction of improved farming techniques and inputs.

Agricultural Labor

The demand for agricultural labor is functionally related to the cropping pattern (pure or mixed and the product mix), the time-distribution of agricultural operations, and the mode of technology used. The sequencing of the various distinct farm operations is used as surrogate for time in the model. Thus, labor is broken down into periods 1 to 7.

Period 1 -- February and March in year t.

Period 2 -- April in year t

Period 3 -- May, June and July in year t

Period 4 -- August in year t

Period 5 -- September in year t

Period 6 -- October and November in year t

Period 7 -- December of year t and January of the following year.

The breakdown is based on seasonal work patterns revealed by a control group of six holdings each in Central region and Eastern region, respectively.[8] The purpose was to use the data as a check on the indirect estimates of labor and other input.

By categorizing the labor working periods in the fashion that follows, periods in which labor supply has a slack become apparent.

Period 1 -- Land clearing, land preparation: February and March

Period 2 -- Planting, fertilizing: April

Period 3 -- Cultivating and weeding: May, June, July

Period 4 -- Harvesting of maize, vegetables and part of yams: August

Period 5 -- Harvesting of yams, maize: land clearing, preparation for minor season crop: September.

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[8] A control group of 12 farmers, six in Central region and six in Eastern region was selected for day to day observations of farming operations. One enumerator was assigned to live with one holding to observe on a day-to-day basis the following:

a) Labor: The number of household members working in a specific field, type of work done, hours put into it, the age, sex of the worker. Similar data were collected on hired labor.
b) Work on Farms other than holding: Number, age, sex, time worked and wage.
c) Work off-farm: craft, trading and services--number, age, sex and length of time worked.
d) Walking distance to farm and time taken.

Period 6 -- Harvesting of yams, portions of cocoyams, cultivation of minor season crop: October and November

Period 7 -- Harvesting of yams some cocoyams, minor season crop, cultivation of minor season crops. Included also is the harvesting of some plantains and cassava: December and January.

Cassava and cocoyams undergo continuous harvesting when they mature with the ground serving as storage space. Once harvested, the crops are often immediately replanted to begin another cycle of production and harvesting. For reasons yet to be explained by agronomists, the same variety of plantains planted at about the same time have different maturing dates. The fruit is harvested by cutting down the plant and later another seedling sprouts to begin a new cycle of production and harvesting.

Thus, plantains, cassava and cocoyams are the crops often left in bush fallow while the farmer moves to a new cleared area for farming. The LP model was designed to harvest some of the crops in the seventh period. In Table 4.1, for instance, 60 bunches of plantains were harvested at the end of the crop year with 60 more bunches to be harvested every six months for the next eighteen months, resulting in an average yield fo 250 bunches (see M-C-P-O-column). Labor used for subsequent bush fallow maintenance and harvesting is provided from the overhead labor available in the subsequent farming seasons much the same way as part of the overhead labor in the current farming year is used to maintain bush fallow of the previous year.

On-Farm Labor Estimation

The number of hours of farm work per head varies from four to nine hours a day, and it is a function of sex, age, walking distance to the field from place or residence, weather (in particular, rain). Thus, two major assumptions were utilized to estimate man-hours per head used in farm operations: 1) that physical labor productivity is positively correlated with age group and sex, and 2) women have lower physical productivity than men [Norman, 1973].

There are certain factors that contribute to the productivity of the farmer worker--whether hired or family worker: health, nutrition, incentives, climate. By far, the most limiting ones observed during the survey appeared to be nutrition, climate and distance. The nutritional factor was considered too complicated to handle and, therefore, is not included in this study. However, climate (rain days) and walking distances are taken into consideration in estimating family farm labor supply.

By using farm work-hours, heterogeneous labor was converted into a more homogeneous input of an eight hour day for a man equivalent. Treating labor as a homogeneous resource using arbitrary weighting systems might be questioned on the grounds of being arbitrary. Consideration was given to the fact that specific tasks might be performed by specific type of labor and that the roles might not be interchangeable.

Three distinct labor constraints were derived: Family labor available for farm work; family labor for off-farm work; and overhead labor. The following weights were applied in the determination of the availability of family on-farm labor.

Table 4.9. Weights (C_i) for Conversion of Different Age-Sex Cohorts in Man-Equivalent Units.

Sex	Age Groups							
	11 and Under	12-16	17-50+	17-55*	56-66*	56-70*	Over 66+	Over 70+
Male	0	.5	--	1		.5	0	0
Female	0	.5	.75	--	.5	--	0	0

*Cohorts for male sex only
+Cohorts for female sex only

Source: Synthesized from data found in the literature (e.g., Yotopoulos (1967) and Norman (1972)).

Off-Farm Labor

In order to estimate the availability of family labor for off-farm employment, an attempt was made during the survey to estimate the hours devoted to work outside the farm. The stock of the hours of labor available for off-farm work entered the linear programming model as a resource which could be salvaged at the ongoing off-farm wage rate.

Labor Overhead

The farmers encountered in the survey generally walked half an hour from the places of residence to the farm.

Every visit to the farm reduces the work day by one hour. Another component of the overhead labor was labor used to perform routine tasks not directly related to current farm operations such as 1) maintenance and harvesting of crops in bush fallow; 2) fishing for crabs and collection of wild mushrooms; 3) gathering of firewood to be used as fuel.

Money Capital Constraint

In general, operating capital (cash available) is a limiting factor and is said to be inhibiting farm expansion. In this study, cash expenses were used as an indication of the amount of operating capital. The restriction on funds available for cash expenses was set equal to the amount actually spent for crop producton and food consumption during the year of inquiry 1972-73, i.e., the expenses on inputs such as hired-labor, farm implements, seeds and fertilizers.[9]

Output Balance

The equality sign of the output balance equation indicates that the total production of the jth crop is exhausted by the consumption, sales and additions to it through food buying. The sign of the technological coefficient (here,

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[9]Though the farmers generally produced their own planting materials, these planting materials were assigned imputed value to reflect how much they were worth in money terms if sold in the market. This procedure was in accord with the practice used in farm management studies in developing countries (e.g., Yotopoulos, 1970).

yield per acre) in the intersection of the relevant row vector and column activity is negative.

Borrowing

The farmers were restricted by the amount of money they actually borrowed from money lenders and from friends and relatives during the survey period. None of the farmers interviewed had access to institutional credit operated by the Agricultural Development Bank.

Food Consumption Constraint

The levels of consumption of the commodities occurring in the model were derived from a specially designed household food consumption survey. The holdings or the farm households were visited twice a week by the enumerators for a period of 12 weeks to collect data on consumption of own products, purchases, sales, gifts received and give-aways. These data were aggregated to obtain the average consumption of the household per year and per period as defined in the study.

The limitation in incorporating consumption constraint in the model should be recognized. Because of the short-time span used for the consumption study, seasonal consumption patterns were not derived. Nor was the influence of prices on the consumption of products such as maize, yams, plantains and cassava considered. A better estimation procedure would have been to use time series data to exogenously estimate consumption requirements. A general hypothesis

implicit in this approach would be that the consumption of representative farm household for a given commodity is determined by:

1. past year family cash income;
2. family size;
3. farm size, as proxy for assets;
4. past year's output of that commodity;
5. current price of that commodity;
6. past year's output and current price of the nearest substitute and/or complement of that commodity.

This approach, however, could not be used because of the absence of time series data.

Non-Negative Constraints

None of the activities discussed above can be operated at negative levels.

Phase II--The Poly-Period LP Model

The general framework of the analysis and the construction of the model used in Phase II portrays, essentially, the capital accumulation characteristics of a typical subsistence producer. It is the purpose of this phase to show 1) the interdependence between production, consumption and investment; 2) how unlimited opportunities to borrow money capital and the timing of borrowing can affect the optimum organization of resources; and 3) how the timing of crop sales through the operation of storage activities can enlarge

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the capacity to increase farm income. A planning horizon of one crop year comprising of two cropping seasons--major season and minor season--was chosen and was broken into seven periods to coincide with the various farm operations explained on page 69.[10]

The matrix used is an expanded version of the matrix used in Phase I. Seven operation restrictions were incorporated for each consumption output and cash-in-hand restrictions. There were seven rows for each output restriction and consumption. The food consumption rows specify minimum levels of each crop for each period. Seven cash accounting rows were added. The model also allowed money capital borrowing by periods (period 7 is excluded), food sales, purchasing and consumption by period and storage or output transfer by period. The details of these operational activities are given in the discussion that follows.

The Objective Function

The objective function specified for the Phase II model is

$$\text{Max}\pi^1 = \pi + X_1 - \sum_{i=1}^{6} r_i X_{2i} \qquad i = 1,\ldots,6$$

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[10] As explained previously, the crop year ended with portions of plantain and root crops harvested with the rest of the crops left to grow in bush fallow.

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Where:

X_1 = Represents "start cash" and has a coefficient of 1 and an objective value of -1.

X_{2i} = Borrowing activities from periods 1 to 6.

r_i = The relevant discount factor for rate of interest in the ith period.

π = Profit as defined in the objective function in Phase I. It has an objective value of 1.

All other activities in the model have zero objective values.

Additional Activities

Cash Flows

In Table 4.6, the financial activities and the associated row vectors are shown. The function of the coefficients in the "start cash" is to ensure that the initial starting capital is repaid at the end of the period. The values of the objective coefficients serve to indicate that any borrowings during the first six periods are repaid in the seventh period.

The model identifies the nature of the dynamic interdependence between sales and purchases. The sale of output or family labor adds to the stock of cash available and relaxes the relevant constraint. Contrariwise, labor hiring, input purchasing, food buying and land clearing reduce cash available. Capital borrowing, however, adds to the stock of operating capital.

The Phase II model is a type of non-block recursive

model[11] that considers the farm-household activities as a dynamic system with significant interdependencies. Money capital is used to purchase factors of production, including labor and to buy food. The level of production, consumption and financial activities is restricted by the amount of money capital (CASHP) available to the farm firm at the beginning of each period. The money capital in any period is generated from net cash receipts from sales in (t-1) period, past household savings (cash at hand) and current borrowings. Period 1 seems to be the crucial period when cash is needed most to finance farm operations such as land clearing. There are two sources of cash available to the farmer in this period, net cash receipts from past sales and credit. Since farmers have to meet their planned household consumption needs also from cash from past sales, the amount of starting capital made available to them is severely limited.

Accordingly, the multi-period model in Phase II makes no assumption as to the amount of credit the farmer receives. In Phase I, this amount was restricted to ¢15.0 per acre which reflects the Agricultural Development Bank's lending policy. In Phase II, however, the model is programmed to determine how much credit is needed initially (Table 4.6). The representative farm has a starting capital of ¢250 from the farm's savings.

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[11] Reference has been made to this new concept used to depict household-firm interdependence on page 11 footnote.

Storage Activities

Of the six crops covered in this study, only maize, yams and dried pepper can be stored and sold at a later date. When this occurs, these commodities are stored either on the farms or at places of residence in simple structures. Cassava and cocoyams do not store well; but, it is possible to stagger the harvesting of these crops in the ground or the earth acting as storage space for them. The harvesting of plantains can similarly be staggered, but not to the same extent as cassava and cocoyams. However, in the semi-processed form, such as plantain and cassava chips, the commodities can be stored for a longer period.

There are marked price fluctuations during the year for maize, with depressed prices occurring, as expected, immediately after harvest and relatively high prices prior to the next harvest. As the Nathan Consortium Sector Studies indicate, the uncertainty with regards to the structure and timing of storage operations by the farmers largely accounts for this price behavior [Nathan, Annex VII, Vol. 1, 1970].

The seasonal price patterns are quite a predictable phenomenon and provide an incentive to store the crops for later sale, but the capacity to do so is limited by the storage losses [Ministry of Agriculture, April 1971]. An on-the-spot FAO study documents the nature and extent of these storage losses [UNDP, 1969]. The report indicates that approximately eight to fifteen percent of the crop is

lost during storage. For the portion of the crop that is stored, the average attrition from losses may run to 30 percent. Table 4.10, presents a schedule for determining the rate of storage losses for two types of storage operations--with insecticide treatment and without insecticide treatment. These values were adjusted and used as the transfer coefficients for the Category II and Category I farm, respectively.

The returns on storage calculations shown in Table 4.10 indicate that even when maize is stored, it is economical to make the period of storage short (three to five months). The LP model, therefore, assumes that storage operations for the major season maize ends at the end of period seven. Minor season maize, harvested in the seventh period is sold in the seventh period. Similarly, storage operations for yams and cocoyams commence in the sixth period when their harvesting takes place. In the model some cassava, cocoyams and plantains are harvested at the end of the current farming season. The rest undergo staggered harvesting (i.e., with the ground acting as storage space for cassava and cocoyam), the overhead labor in subsequent farming seasons providing the labor for maintaining the crops and harvesting them. However, the average yields over a complete production cycle (assumed two and one-half years in case of plantains and 24 months in the case of cassava and cocoyams) are used to estimate the overall profitability of the farm business.

Table 4.10. Relative Value of Maize Storage.

Sale Month	Relative Value (Without Treatment)		Relative Value (With Treatment)	
	Relative Value	Return on Storage (Percent)	Relative Value	Return on Storage (Unit)
August-Sept.	97.3		97.3	
October	88.9	2.6	94.4	7.5
November	83.3	10.3	93.4	24.7
December	75.7	6.8	92.4	6.8
January	67.3	- .02	92.4	-10.9
February	58.3	-18.3	92.4	-56.5
March	50.1	-34.6	92.4	-62.0
April	45.6	-26.7	92.4	-61.1
May	41.8	-16.9	92.4	-59.0
June	38.6	-17.7	92.4	-59.8
July	38.0	-33.2	92.4	-58.2

Source: Ministry of Agriculture Report Annex 12, pp. 6-7.

Appendix Table A.1 summarizes the sales, consumption and storage activities for maize for Category II representative farm in the Brong-Ahafo region.

The behavior of the farmers as empirically documented by the Nathan [1970] study and also observed in the survey for this study is that the average farmer builds some form of physical facilities to store commodities such as maize and yams. The Nathan Consortium Sector Study estimated that approximately 30 percent of the maize crop in Ghana is stored for household consumption, 45 percent sold at harvest time and 25 percent stored for sale at a later time. Nyanteng

[1972] reports that in general, yams intended for market may be stored for a period of about three months. Data collected in his study reveal that over 80 percent of the farmers interviewed sell their yams within two months after harvest (in our LP model, this coincides with selling yams in period seven). Cocoyam, like cassava, is generally left to stand in the field and harvested when there is a need for it. Occasionally, however, large quantities may be harvested and stored in a heap underground or on the ground and covered with leaves for periods ranging up to about three months. Pepper is often harvested, dried and stored in baskets or in bags.

In general, if the marginal cost of storage in any period is less than the marginal revenue from storage, it would be profitable to store. The macro-effect of storage is to dampen seasonal price fluctuations but the model does not deal with this aspect.

A recent survey conducted by Nyanteng and Apeldoorn [1971] in the Mampong-Atebubu agricultural districts (also covered in this study) showed that the main marketing problems of the farmers centered around the place and timing of sales.

The storage submodel used in this study is aimed at providing guidance on the timing of sales with due regards to the rates of return on storage. It did not, however, deal with the macro-effect of storage operations on prices.

Phase III--New Technology

In phases I and II, the cropping activities used were those actually engaged in by the farmers, the associated coefficients being the averages for the sample in each situation. The Phase III model was an enlarged Phase II model including pure-stand cropping activities that which used recommended modern cultural practices. Two alternative ways of producing one pure-stand crop were recognized and included in the model. Among the recommended practices were farming operations such as plowing and harrowing of land, using custom-hired tractors and the substitution of weedicide for manual labor in weeding the far removing weeds from the farms. Several labor hours are required to weed one acre of the farm by means of manual labor. The application of herbicide is thus tantamount to introducing a labor-saving technology into the farming operations. Thus, alternative cropping activities were established for each crop: One activity using the recommended practices with the exception of weedicides (alternative 1) and the other including weedicide in the cropping operations. Examples of two such alternative activities are MAZA2 (pure-stand maize, alternative 1) and MAZA3 (pure-stand maize, alternative 2). The input output coefficient used derived from the "Farm Planning Manual" published by the Department of Agriculture, University of Ghana. Table 4.7 summarizes the activities and restraints added to the Phase II model.

Concluding Remarks

The programming models had three components: The activity set, the constraint structure and the objective function. The elements of these components of the programming models have been identified and discussed in this chapter. We started with the Phase I model--a static linear programming model. The Phase II model was a poly-period model, but essentially, it was an expanded version of the Phase I model. Lastly, the Phase III model was also an expanded version of the Phase II model. The main purpose was to enable us to find out what the optimal farm organization and income would be if the farmers followed and recommended cultural practices. It is expected that the last model will enable us to know how competitive crops produced under advanced technology are as against crops produced using indigenous technology. We are also mindful of the fact that in Phases I and II maize is the only crop produced as a pure-stand crop. If our expectation that crop mixtures are normally preferred by the farmers because in addition to reasons such as security considerations they offer greater composite monetary pay-off. The shadow prices of the programmed results will enable us to know what the situation really is. In the chapters that follow, the programmed results will be summarized and analyzed so that we can draw the necessary policy related inferences.

CHAPTER V

OPTIMUM FARM ORGANIZATION WITH EXISTING RESOURCE AND RESPONSE COEFFICIENTS

The preceding chapters have provided the framework for analyzing the economics of resource use on farm in selected areas of Ghana. Specifically, the issues raised were focused on 1) resource use and acquisition needed for increasing agricultural outputs and incomes in the study areas; 2) resource utilization and profit maximizing plans consistent with initial resource endowments and expanded resource use; 3) competitive position of improved technology vis-a-vis a modified historical technology of production or "transitional technology"; 4) dynamic interdependence between production, subsistence consumption and investment/ disinvestment; 5) the use of on-farm storage operations as an additional means of optimizing farm income and 6) labor use efficiency.

In order to achieve these objectives, the analysis of the representative farms was effected through three empirical phases. Phase I used static LP to determine proft maximizing plans consistent with the initial resource base. Later, seven alternative resource restraints were used to

determine the effect on farm organization and income of resource expansion.

The poly-period model used in Phase II made use of the same initial restrictions with consumption, output balance and cash availability constraints broken down into seven periods. One major departure from the Phase I static model was the elimination of the borrowing constraint so as to allow the model to determine the timing of borrowings and their optimum levels. Four alternative resource constraints were examined in this phase. They were 1) the initial resource situation; 2) increment of labor hiring coefficient from .66 to 1.0; 3) allowing land clearing with minimum maize acreage and 4) allowing more land clearing without a minimum maize acreage.

Lastly, the Phase III model, also a poly-period one, was used to incorporate alternative cropping technologies as parallel activities. The addition of modern technological crop activities was designed to ascertain what farmers should do if they want to exploit the full opportunity set of cropping activities available for maximizing their income.

This chapter presents the resulting optimal organizations of the representative farms for all the three phases. The optimal organizations were based on a simple average of product and input prices as obtained in the years 1971 and 1972 in Ghana. The yields used were biological yields obtained through "yield plot" studies. With the exception

of the Phase III model, only those cropping activities were included which were actually used by farmers in the sample in 1972-73. For the technological coefficients in Phases I and II, the sample average for each representative farm was used.

The validity of the optimal solution in each situation will depend on the realism of the assumptions made with regard to prices, yields and other coefficients used in the study. For instance, the biological yields used could depart from the actual yield experienced by the farmers. Most of the yield losses encountered in the study areas occur through rodent attacks on the crops (a phenomenon which could reduce yield as much as 30 percent) and through poor harvesting or complete failure to harvest crops. Rodent attacks on crops could be minimized through the construction of fences. The cost of constructing fences or the opportunity cost incurred for not providing fences (as indexed by the monetary value of the crop losses) could properly be considered as aspects of the fixed cost components. Other fixed costs include depreciation on storage barns, the cost of road maintenance and taxes (usually varied from locality to locality). They amounted, on the average, to 50 percent of gross revenue. The inflation occuring in Ghana also needs consideration while evaluating the gains made by the optimization procedure. The 1971 devaluation of the cedi resulted in general price inflation with much of the benefits accruing to producers

of staple food products while at the same time the government maintained subsidies on essential agricultural inputs. With high food prices and relatively low input cost, the terms of trade, as reflected in the optimization solution, favored agriculture. Notwithstanding, these considerations and the question of stochastic elements (excluded from the model) the optimization solution points to the potential income attainable with resources organized in the optimal fashion.

Generally, in an LP solution, each limiting resource is assigned an "opportunity cost" or shadow price equal to its value in its most profitable use. The shadow prices of limited resources are the MVP's of the respective resources, i.e., the change in income attributable to the last unit of the resource employed. Simply, the shadow prices pertaining to the slack, surplus and artificial variables indicate the rate of change in the objective value in a positive as well as negative direction. In mathematical terms also the shadow price is the partial derivative of the objective function with respect to unit change in resource availability or requirement. These changes generally apply over a small range of availability of the resource.

The MVP derived from programming would appear analagous to MVP derived from a continuous function in the sense that they both would indicate the pressure to expand or contract a particular resource. However, a caveat need be sounded

in the interpretation and application of the MVP from programming. The two types of MVP's are not quite the same. In programming, the MVP is evaluated at the margin with no other resource restricting [Lard, 1963]. Nonrestricting resources are free and can combine with one more unit of the restricted resource to yield the MVP of the resource. The MVP from programming represents the rate of change in the objective function for one additional unit of the resource and its behavior for further additional units of the resource may be erratic, depending upon which factors become restricting as output changes. The erratic behavior is attributed to the corner solution of the LP, i.e., the solution holds for specific range until other resources become limiting, then another organization becomes optimal and MVP's of resources change.

This caveat is necessary in guiding the users and readers of the programming results derived in this study. Though the MVP's reveal the pressures to expand or contract a given resource, these pressures do not unravel how far adjustment need be made or the range over which the MVP's hold. The MVPs have relevance only within the confines of the constraints and objective coefficients specified in the model.[1]

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[1]The MVP's of resources derived from continuous functions also have their limitations. The MVP's derived from Cobb-Douglas functions, for instance, are estimated at the geometric mean of the resources, thus limiting their usefulness as planning guides.

The next two chapters will focus on the issues involved with resource expansion. Chapter VI will discuss the effect on income and farm organization of alternative resource expansion for the representative farms delineated in the study. Chapter VII will conclude the thesis with a discussion of the policy implications of the results of the programming models followed by summary, conclusions and recommendations.

Programmed Solution of Phase I Results by Category and by Region

Table 5.1 contains the relative performance of Category I or indigenous farms on the following economic measures: gross income, gross return per acre, gross return per man hour and gross return per capital. The proximity of the study areas in the Eastern and Central regions to an important national market is reflected in the relatively higher producer prices received by the farmers as compared with their counterparts in the other regions. The gross return per acre was highest in the Central region and lowest in the Brong-Ahafo region. The same pattern existed for the gross returns per hour and per capital. Clearly, there was a great premium for locating a farm in areas near important consuming centers, such as Accra, the capital and Koforidua an important market center.

The resulting crop plans for the Category I farms were laterally diversified, minor season maize being the

Table 5.1. Characteristics of and Optimal Organizations for Category I Farms, All Regions, Ghana 1972-73.

Activities	Unit	Brong-Ahafo	Ashanti	Volta	Central	Eastern
Sell Labor Period 1	Hrs	244	245	146		163
Sell Labor Period 3	Hrs	142	306	219	220	244
Sell Labor Period 4	Hrs		142	66		81
Sell Labor Period 5	Hrs	122	163	73	104	81
Sell Labor Period 6	Hrs	244		146	0	0
Sell Labor Period 7	Hrs	160	167	146	0	0
Hire Labor Period 2	Hrs	0	675	91	558	365
Hire Labor Period 6	Hrs	0	84	0	0	0
Hire Labor Period 7	Hrs	0	0	0	0	0
Sell Maize (dry)	200 lb	19.1	13.4	7.7	6.0	14.8
Sell Maize (veg)	220 lb	1.9	1.3	.8	.6	1.5
Sell Cassava-bag	200 lb	33.3	56.4	39.0	56.7	56.25
Sell Plantain	Bunch	862.0			459	556.0
Sell Cocoyam-bag	120 lb	146.0	55.9	44.1	52.69	43.3
Sell Yam	100	.76	34.4	11.7	18.4	15.6
Sell Pepper	lbs	1528	---	780.0	1021.9	
Borrow	¢	---	86.3	14.8	12.3	53.9
Buy Plantain	Bunch		84.0			
Buy Vegetables	lbs				65.0	
Enterprise						
Maize (Minor Season)	Acre		1.2	1.75		2.0
MCO	Acre	1.5				
MCOY	Acre		3.75			
MPOV	Acre	4.6				
MCPOY	Acre					2.95
MCPOYV	Acre				3.6	
MCOYV	Acre	.21		2.0		
MPOYV	Acre					

	Unit	Brong-Ahafo	Ashanti	Eastern	Central	Volta
Constraints						
LANDM1	Acre	6.41	3.75	2.95	3.58	2.0
February-March Labor	Acre	766	545.0	384.0	273.0	317.0
April Labor	Acre	433	334	343	434	338
May-June-July Labor	Acre	1515	992	1025	1282	656
August Labor	Acre	599	312	224	372	300
September Labor	Acre	185	242	212	152	173
October-Nov. Labor	Acre	864	617	597	506	527
December-January Labor	Acre	5038	562	532	521	444
Annual Labor	Acre		3610	3316	3940	2755
LANDM2	Acre	2.0	1.2	2.0	---	1.75
Cash	¢	60.0	107.8	69.69	103.65	27.0
Borrowing	¢	125.19	86.25	53.9	12.34	14.8
Consumption						
Maize	220 lb	.823	1.03	1.95	1.91	5.13
Cassava	200 lb	3.03	3.56	4.0	5.55	7.02
Plantain	Bunch	40.52	84.0	47.0	34.96	45.2
Cocoyam	120 lb	4.33	4.9	6.9	1.76	1.9
Yam	100	.943	1.55	.62	.26	1.27
Pepper	lb	60.0	62.0	65.0	70.0	80.0
Gross Income	¢	1798.3	1304.3	1867.24	1824.04	1104.3
Gross Return/acre	¢	285.44	263.5	377.2	506.77	294.4
Gross Return/Hr	¢	.36	.30	.5	.445	.38
Gross Return/capital	¢	14.36	6.72	15.11	15.73	13.63
Labor hrs/Acre	Hrs	800	881.0	744	1138	758
Ratio of hired labor total labor inputs	%	0	17.22	9.22	15.76	3.2

Legend
M = Maize
C = Cassava
P = Plantain
O - Cocoyam
Y = Yam
V = Pepper
Maize (veg) = Fresh maize
¢ = Cedis (currency)

Source: Computed

only sole crop raised. Brong-Ahafo had six crops with maize-cocoyam-cassava mixtures being allocated 1.5 acres and 4.6 acres for maize-plantain-cocoyam-pepper mixtures. All household food consumption requirements were met from home production. The crop sales figures given in the "activities" section of Table 5.1 were the net after consumption withdrawals. Category I farms in the Ashanti region were diversified also with five crops--maize in the minor season (1.2 acres) and maize-cassava-cocoyam-yam mixtures (3.75 acres). Since plantain did not appear in the cropping plan, 84 units of it were purchased to satisfy the consumption constraint. Without a food purchasing activity in the model, the plan would have forced in a cropping activity that included plantain. The competitive position of cropping activities not included in the optimum plan is shown by the size of their shadow prices.[2] The marginal costs associated with the nearest competitive

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[2]Generally, the simplex procedure continually strives to find a better operating strategy than the one currently at hand. It does so by reviewing at each step of the solution the marginal cost reduction or profit potential of all the activities that are not in the current solution. The simplex procedure determines what activities to include to improve solutions and ultimately, to find optimum solution. It is on the basis of this activity selection that the procedures finally stops and determines that an optimum solution has been found. The procedure also determines in each stage the rate at which income will decrease if it were to introduce unprofitable activities into the solution. There are many names given for this unprofitableness of each of the activities that are not part of the solution: Marginal cost, shadow price, opportunity costs, multipliers, π values and dual variables. Reference here emphasizes the enterprise's competitive position under different cropping patterns

enterprise involving plantain not in the solution space was ¢107.7. Therefore, to force one unit of plantain activity into the solution would have reduced the optimum income by ¢107.7 per unit. Similar reasoning applies to Category I farms in the Volta region which had diversified cropping with maize, cassava, cocoyam, yam and vegetables, but excluding plantain. The central region also had 3.6 acres allocated to maize-cassava-plantain-cocoyam-yam-vegetable mixtures. All food consumption requirements were satisfied. In the Eastern region, 2.0 acres were allocated for maize (sole crop) and 2.95 acres to maize-cassava-plantain-cocoyam-yam mixtures.

The shadow prices associated with maize as a pure-stand crop in the major season were ¢241.0 per unit (Ashanti region), ¢534.00 per unit (Eastern region), ¢516 per unit (Volta region), ¢462.0 per unit (Central region) and ¢58.0 per unit (Brong-Ahafo region). In addition to the several noneconomic arguments that could be used to justify crop-mixtures, the shadow prices quoted above show that from purely economic standpoints, it is "too expensive" for the farmers to raise maize as a pure-stand crop on a major season land. The quoted shadow prices show the degree of "unprofitableness" of maize as a pure-stand crop in the major season.

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and levels of resources. The higher the shadow price, the lower the competitive position in both the current and alternative optimum plan [Driebeek, 1969, pp. 103+].

Table 5.2 shows for Category II or "transitional" farms in the study areas (Ashanti, Brong-Ahafo, Central and Eastern regions of Ghana) the gross income, family consumption withdrawals and the extent of disinvestment of family labor.

In the Ashanti region, the crop plan was diversified with maize-cassava-plantain-cocoyam-yam enterprise allocated 3.8 acres. The shadow prices associated with the excluded cropping activities, maize (major season), maize-cassava-plantain-cocoyam-vegetables, maize-cassava-plantain-cocoyam and maize-yams were ¢70.4, ¢5.03, ¢11.05 and ¢54.34, respectively. Of the cropping activities mentioned above, maize (major season) appeared the least favored in an alternative crop plan, followed by maize-yam enterprise. Maize, as a pure-stand crop in the major season land, appeared to be ¢70.4 too expensive per unit to be forced into the optimal program.

The programmed crop plan for Category II farms in Brong-Ahafo region selected all the six crops covered in the study. The marginal costs associated with the nearest competitive cropping enterprises were: ¢6.76 (minor season) maize in pure-stand; ¢20.09 (maize-cassava-plantain-yam vegetable mixtures); ¢34.06 (maize-yam mixtures). The shadow price for major season maize in pure-stand was ¢194.38 which shows that this cropping enterprise was the most expensive to be forced into the program.

Table 5-2. Characteristics of and Optimal Organizations of Category 2 Farms Ashanti, Brong-Ahafo, Central and Eastern Regions.

Activities	Unit	Ashanti	Brong-Ahafo	Central	Eastern
Sell Labor Period 1	Hour	116		18	28
Sell Labor Period 2	"				
Sell Labor Period 3	"	248		20	36
Sell Labor Period 4	"	98			10
Sell Labor Period 5	"	196		162	72
Sell Labor Period 6	"	195		38	68
Sell Labor Period 7	"	80			234
Hire Labor Period 1	"		788		
Hire Labor Period 2	"	727	2586	653	343
Hire Labor Period 3	"		4275		
Hire Labor Period 4	"		852	18	
Hire Labor Period 5	"		1015		
Hire Labor Period 6	"		976		
Hire Labor Period 7	"		760	10	320
Sell Maize	220lb	20.2	105.5	21.4	27.4
Sell Cassava	200lb	72.4	190.6	136.2	87.7
Sell Plantain	Bunch	982	1935.0		593.2
Sell Cocoyam	120lbs	70.2	318.8		70.6
Sell Yam	100	36.4	77.4	26.9	18.3
Sell Vegetables	lbs		2299	45.8	
Borrow	¢	123.0	346.65	104.5	78.4
	AC				
Enterprise	"				2.0
Maize (Minor Season	"	.1		3.9	
MCY	"			.2	
MCV	"		7.5		
MOYV	"		9.9		
MCPO	"	3.8			3.2
MCPOY	"				
MCPOYV					

	Unit	Ashanti	Brong-Ahafo	Central	Eastern
Constraints					
February-March Labor	Hrs	351	1086	260	269
April Labor	"	384	551	297	432
May-June-July Labor	"	1089	1641	468	960
August Labor	"	212	518	274	203
September Labor	"	196	527	193	166
October-Nov. Labor	"	669	1048	376	726
Dec-January Labor	"	591	999	426	702
Annual Labor	"	3492	6370	2295	3460
Land (Major	AC	3.79	17.34	4.97	3.22
Land (Minor	¢	---	---	---	2.0
CASH	¢	87.0	250	74.61	125.0
Borrowing		123.0	346.65	104.55	78.35
Consumption					
Maize	220lb	.90	.823	1.65	2.39
Cassava	120lb	3.4	3.03	4.8	4.6
Plantain	Bunch	116.36	40.52	32.5	54.0
Cocoyam	120lb	5.6	4.3	2.4	7.3
Yam	100	1.55	.943	.22	.7
Vegetables	Lbs	60.0	60.0	65	68.0
Gross Income	¢	2068.3	5070.3	2028.7	2662.3
Gross Return/Acre	¢	544.28	291.4	471.8	511.98
Gross Return/Hr	¢	.49	.29	.685	.52
Gross Return/Capital	¢	9.85	8.5	11.32	13.08
Labor Hrs/Acre	Hr	1110	1013.0	688.0	994
Ratio of hired labor total labor inputs	%	17.0	63.8	22.41	6.6

Legend
M = Maize
C = Cassava
P = Plantain
) = Cocoyam
Y = Yam
V = Pepper
¢ = Cedis (currency)

Source: Computed

In the Central region, the cropping plan was also diversified with four crops--maize, cassava, yams and vegetables. The program allocated 3.9 acres to the maize-cassava-yam mixtures and only 0.2 acres to the maize-cassava-vegetable mixtures. A comparison of the shadow prices of the excluded cropping activities shows maize in the major season as a pure-stand crop was the next favored enterprise which could be considered. Its marginal cost was ¢60.66 as compared with ¢99.2--minor season maize in pure-stand and ¢212.02--maize-cassava-plantain-cocoyam-vegetable mixtures.

In the Eastern region, 3.2 acres were allocated to the maize-cassava-plantain-cocoyam-yam mixture and 2.0 to the production of maize in the minor season as a pure-stand crop. Maize, as a pure-stand crop, was the most expensive cropping enterprise to be considered for inclusion in the optimal program. It had a shadow price of ¢664.7 associated with it. The next favored cropping enterprise which could be forced into the solution was maize-cassava-cocoyam-yam mixtures. It had a marginal cost of only ¢15.0 associated with it.

The possibilities of varying family labor (as a fixed asset) were considered through the use of the asset-fixtiy theory [Johnson, 1970 and Clark Edwards, 1959]. The theory states that an asset or resource becomes fixed when the following condition is met:

$P_x$acquisition $\geq$ MVP_x $\geq$ $P_x$salvage.

where x is the resource, P_x acquisition is the purchase price of acquiring one more unit of the resource, MVP_x is the margional value product of x in production and P_x salvage is the disposal or sale price. When the MVP_x is less the salvage price, it is profitable to use less of x (or sell x by varying its quantity downward). When the MVP of x is greater than its acquisition price, it is profitable to acquire more of x (or the quantity of x varies upward).[3]

In Brong-Ahafo, for instance, no labor hiring activities took place in any of the periods among Category II farms in that region. An examination of Table 5.3 shows that the MVPs were consistently higher than corresponding acquisition prices per unit of labor. However, among the Category I farms, there were substantial sales of family labor (Table 5.1), the MVPs of seasonal labor again indicating when it was profitable to sell family labor (Table 5.4a). In Ashanti, labor selling activities took place in all the seasons for both categories of farms, except period 2 in the case of Category II farms and periods 2 and 6 in the case of Category I farms. These were periods when the MVPs of seasonal labor were higher than its acquisition cost. Similarly, for both categories of farms in the Eastern and

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[3]Here and in subsequent discussion, the MVP's should be interpreted with the caveat previously raised in mind. The holds for one unit of a particular resource and its behavior be erratic for further additional units of the resource.

Table 5.3. Comparison of MVPs, Salvage Values and Acquisition Cost of Labor by Region, Ghana, 1972-73, Category II Farms (Cedis (¢)).

Region	Periods						
	P_1	P_2	P_3	P_4	P_5	P_6	P_7
	MVPs in Cedis Per Hour						
Brong-Ahafo	.13	.114	.114	.123	.123	.102	.102
Ashanti	0.0	1.2	.06	0.0	0.0	.06	0.0
Eastern	0.0	.13	0.0	0.0	0.0	0.0	.14
Central	0.0	1.1	0.0	.3	0.0	0.0	1.2
	Salvage Values Per Hour						
Brong-Ahafo	.06	.06	.06	.06	.06	.06	.06
Ashanti	.06	.06	.06	.06	.06	.06	.06
Eastern	.0675	.0675	.0675	.0675	.0675	.0675	1.0
Central	.0675	.0675	.0675	.0675	.0675	.0675	.0675
	Acquisition Cost Per Hour						
Brong-Ahafo	.0875	.075	.075	.0812	.0812	.0675	.0675
Ashanti	.1125	.09	.106	.0938	.10	.0938	.0938
Eastern	.106	.088	.125	.094	.106	.125	.094
Central	.106	.088	.125	.094	.106	.125	.094

Source: The MVPs were derived from the LP solutions. The salvage values or the opportunity cost of family labor were the labor selling prices used as the objective coefficients in the LP The Px acquisition values given here refer to the cost of hiring a unit of labor used in the objective functions of the LP.

Table 5.4a. MVP of Resources: Category I Farms by Region (Phase I).

Resource	Ashanti	Brong-Ahafo	Eastern	Volta	Central
	Marginal Value Products in Cedis				
Cash Expense	.73	10.37	.009	.06	.09
Land (Major)	255.6	0	604.6	565.4	520.3
Land (Minor)	0.80	0	0	49.2	0
Planting Materials					
Maize	.10	.68	.57	.57	.06
Cassava	4.3	28.4	23.66	3.01	2.5
Plantain	1.9	.68	.56	.11	.06
Cocoyam	5.2	34.11	28.4	47.58	3.0
Yam	8.67	51.96	47.3	4.0	5.0
Pepper	2.46	.93	4.7	4.8	.5
Implements					
Matchetes	1.45	7.30	7.95	8.00	.841
Hoes	.67	4.44	3.69	3.7	.39
Axes	1.37	8.98	7.48	7.5	.79
Chissels	.55	3.4	3.03	3.05	.32
Baskets	.52	3.6	2.84	2.85	.30
Labor By Periods					
Period 1	.06				
Period 2	.25	.35	.13	.13	.13
Period 3	.06	.06			
Period 4	.06	.59		.06	
Period 5		.06			
Period 6	.25				
Period 7	.06				

Source: Computed

Central regions, disinvestment in family labor occurred in periods whose MVPs exceeded the acquisition cost per unit of labor.

It is evident from Tables 5.2 that the gross returns per unit of individual resources were high. In the Central region, cash expense, as a resource, had a very low MVP (¢.0001) indicating that it was virtually not restricting. However, in Table 5.3, it is shown that the gross return per unit of capital (i.e., its average return) was 13 times as high as its MVP. As compared with Brong-Ahafo and Eastern regions, the MVP per unit of land in Central and Ashanti regions were relatively low. However, the MVPs of other farm inputs for Category II farms as demonstrated in Table 5.4b for Ashanti and Central regions would point to the high earning power of these inputs. In these two regions, the need for expanding the use of these inputs appears to be clearly demonstrated by the magnitudes of the respective MVPs which were consistently above their respective marginal factor cost. In Brong-Ahafo and Ashanti regions, the MVPs of land (major season) would indicate that greater income gain can be achieved by bringing more major season land into cultivation.

Table 5.4a contains the MVPs of resources used on Category I farms in all the five regions. In Brong-Ahafo region, both major season land and minor season land are not a limitation as shown by zero marginal product. However,

TABLE 5-4b. MVPs of Resources: Category 2 Farms by Region.

Phase 1

Resource	Unit	Ashanti	Brong-Ahafo	Eastern	Central
		----------Marginal Value Produce (¢)			
Cash Expense	Cedi	7.78	1.81	.0001	7.32
Land (Major Season)	Acre	2.41	201.35	744	2.01
Land (Minor Season)	"	0	0	62.5	0
Planting Materials					
Maize	Lb	.52	.17	.06	.50
Cassava	100	21.96	7.01	2.5	20.81
Plantain	Unit	.53	.17	.06	.50
Cocoyam	100	26.35	8.42	3.0	24.97
Yam	100	43.92	14.03	5.0	41.6
Pepper	Lb	20.0	5.6	.5	4.2
Other Inputs					
Fertilizers	Lb	24.6	7.86	2.8	23.3
Matchetes	Single	7.38	2.36	.84	6.99
Hoes	"	3.43	1.09	.39	3.25
Axes	"	6.94	2.21	.79	6.57
Chissels	"	2.8	.897	.32	2.66
Baskets	"	2.64	.84	.30	2.49
Labor By Periods	Hour				
Period 1	"	0	.13	0	0
Period 2	"	1.2	.114	.13	1.1
Period 3	"	.06	.114	0	0
Period 4	"	0	.123	0	.3
Period 5	"	0	.123	0	0
Period 6	"	.06	.102	0	0
Period 7	"	0	.102	.14	1.2

Source: Computed

when compared with the acquisition prices of the other farm inputs, the earning power of the restrictive inputs would appear high enough to warrant an increased use of an additional unit of each of the resources.

Comparison of Results of Phase I with Observed Sample Data: Category I and Category II Farms

The programmed results of Phase I, Category I and Category II farms are shown in Tables 5.4c and 5.4d. They are discussed on a region by region basis. The actual crop plans are given in Table 3.3, Chapter III, which will be referred to often to facilitate comparison.

Category I Farms

In Brong-Ahafo region, the optimum gross income came to ¢1798.3 as against ¢1206.4 from the actual average for the representative farm in the sample. This represents an increase of ¢591.9 or 49 percent. The actual crop plan had pure-stand maize in the minor season whereas the programmed crop plan did not. The program used 6.1 acres of major season land, .7 acres less than the amount available. In Ashanti region, the programmed crop plan for Category I farms in Ashanti allocated 3.75 acres for maize-cassava-cocoyam-yam enterprise in the major season and 1.2 acres for pure-stand maize in the minor season. The programmed income per acre came to ¢344.2 or 39 percent more income than the actual income. The program used all the cash available, including borrowing up to the limit. With a slack showing

Table 5.4c. Comparison of Phase I Results with Observed Sample Data, Category I Farms by Region.

ITEM	UNIT	BRONG-AHAFO		REGION ASHANTI		EASTERN		VOLTA		CENTRAL	
		Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis (¢)	1798.3	1206.4	1304.3	960.1	1867.2	1403.4	1104.3	820.9	1824.04	144.2
Family Labor Used	Hrs	5037	5776	3609	3675	3316	4334	2755	3571	4823	4823
Hired Labor Used	Hrs	0	2064	926	384	365	95	91.0	48.0	262	558
Cash Used	Cedis (¢)	129.19	125.19	107.8	107.8	69.69	69.69	27.0	27.0	103.65	103.65
Borrowed Cash	Cedis (¢)	0	100.5	86.25	86.25	53.9	74.25	53.92	56.25	12.34	91.19
Cropping											
Major Season Land	AC	6.1	6.7	3.75	3.75	2.95	2.95	2.0	2.0	3.6	3.6
Minor Season Land	AC	0	3.0	1.2	3.0	2.0	2.0	1.75	1.75	2.5	0
Change In Income	Per-cent	49		39		29		34		26	

Source--Computed

Legend
¢ = Cedis
Ac = Acre
Hrs = Hours

Table 5.4d. Comparison of Phase I Results with Observed Sample Category II Farms by Region.

Item	Unit	REGION							
		CENTRAL		EASTERN		ASHANTI		BRONG-AHAFO	
		Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis	2028.7	1636.53	2662.3	1934.7	2068	1354	5080	3225
Family Labor Used	Hour	2295	3178	3460	4450	3578	4219	6370	7243
Hired Labor Used	Hour	681	215	343	126	609	432	11072	2264
Cash Used	¢	74.61	74.61	125.02	125.02	87	87	250	250
Borrowed Cash	¢	104.55	104.55	78.4	85.79	63	123	346	346
Cropping									
Major Season Land	Acre	4.1	4.97	3.22	3.22	3.8	4.2	17.4	17.4
Minor Season Land	Acre	0	2.0	2.0	2.5	0	2	0	5.7
Change in Income	%	23.96		37.6		52.7		57	

Source: Compiled.

for the minor season land, the MVP was zero. In the Eastern region, the optimum income was ¢1867.2 as against the sample average of ¢1403.4 representing a gain of 33 percent. The cash expense available was used up to its limit whereas only 27.4 percent or ¢53.9 of the borrowed money amounting to ¢74.2 was used up. All the major season land was devoted to maize-cassava-plantain-cocoyam-yam-vegetable enterprise. Thus, all the farm family's food consumption requirements were provided from its own resources. In the Volta region, the programmed income for the Category I farms was ¢1104.3. As Table 5.4c indicates, this represented an increase of ¢277.4 or 34 percent. All the major season land and the minor season land were used to their maximum limits. The cropping plan did not include plantain which had to be purchased in order to satify the family consumption requirements. In the actual crop plan, shown in Table 3.3 all the family food requirements were met from home production.

In the actual crop plan in this region, the cropping enterprises were so diversified as to produce at least all family food requirements. All the minor season land was allocated to maize. In the programmed crop plan, however, minor season land was left idle, but the major season land was used to its limit and was allocated to maize-cassava-plantain-cocoyam-yam enterprise. The programmed income came to ¢1824.02 representing an increase of ¢382.04 or 26 percent.

Overview

On the examination of Tables 3.3 and 5.4c, it is clear that the programming procedure has selected fewer crop enterprises than were actually observed in the sample. Pure-stand maize on major season land was completely eliminated from all the crop plans. It is evident that the programmed crop plan did not find maize, as a pure-stand crop on major season land, competitive with the crop mix enterprises.

The gross income increase by programmed allocation of resources in the Category I farms in the study areas were from 26 percent in the Central region to 49 percent in Brong-Ahafo region above the observed incomes.

Category II Farms

The programmed results of Category II--transitional--farms are shown in Table 5.4d. The actual or sample crop plans for the representative farms can be seen on Table 3.3, Chapter III. It will be recalled that the sample farms in Volta region did not meet the main criterion for the specification of Category II representative farms, viz., the adoption of some improved practice such as the use of fertilizers. Thus, both here and subsequent discussion of Category II or transitional farms exclude Volta region.

In Brong-Ahafo region, the programmed income for Category II farms in Brong-Ahafo region was ¢5070.0 with the actual being ¢3255. An income gain of 57 percent was

effected. On examination of labor inputs, it is evident that in the optimum plan, the amount of hired increased from 2,264 hours to 11,072 hours. Cropping activities, including yams, tend to require a great deal of labor, for instance, for preparing yam mounds. The 7.5 acres allocated to maize-cocoyam-yam and vegetable enterprise required a large increase in hired labor.

The programmed plan in Ashanti region allocated 0.1 acres to pure-stand maize in the minor season and 3.8 acres to maize-cassava-cocoyam-yam enterprise. The resulting programmed income of ¢2068.3 represented an increase of 52 percent income over the actual income of ¢1354 observed for the sample. The hired labor inputs also increased from 432 hours to 609 hours in the programmed solution.

In Eastern region, the programmed crop plan for the Category II farms in the Eastern region allocated 3.2 acres to maize-cassava-plantain-cocoyam-yam enterprise. Also, 2.0 acres were allocated to pure-stand maize in the minor season. As compared with the sample crop plan given in Table 3.4, it is obvious that the optimum plan selected fewer enterprises. The programmed income of ¢2662.3 was 37 percent more than the average income for the sample (¢1934.7).

The total programmed income for the representative farm in Central region was ¢2028.7 as against ¢1636.53 in the actual plan. This represents a gain of 23 percent.

Both expenses and borrowed funds were used to their limits. The minor season land remained unused and there was also a slack of 0.87 of the major season land. Land obviously was not a constraining factor for this category of farm.

Regional Comparison of Income and Farm Organizations by Technological Category Actual Versus Programmed

The income increase by programmed allocation of resources for all representative farms is given in Table 5.4e. In the case of Category I farms, the increase ranged from 26 percent to 49 percent. The range for Category II farms was from 23 percent to 57 percent.

These income increases are subject to a gamut of interpretations. Here, we shall attempt some hypothetical, but reasonable explanation for the observed divergencies in income. While no definite conclusions can be reached in the absence of the requisite data, this brief discussion will highlight areas that need research.

The model used in the study discounted the question of risk and uncertainty. The technological coefficients used in the study reflected the weather conditions that actually existed. But, some measure of uncertainty might have been present influencing the decision-making of the farmers.

On the examination of the data in Table 5.4e, a definite pattern emerges. In both categories of farms, the income increase in Eastern, Central and Western regions

Table 5.4e. Gross Income: Actual and Programmed Category I and Category II Farms, All Regions.

ITEM	UNIT	R		E	G	I	O	N	
		CENTRAL		EASTERN		ASHANTI		BRONG-AHAFO	
		Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis	2028.7	1636.53	2662.3	1934.7	2068	1354	5070	3225
Family Labor Used	Hr	2295	3178	3460	4450	3578	4219	6370	7243
Hired Labor Used	Cedis	681	215	343	126	609	432	11072	2264
Cash Used	Cedis	74.61	74.61	125.02	125.02	87	87	250	250
Borrowed Cash	Cedis	104.55	104.55	78.4	85.79	63	123	346	346
Cropping									
Major Season Land	Acre	4.1	4.97	3.22	3.22	3.8	4.2	17.4	17.4
Minor Season Land	Acre	0	2.0	2.0	2.5	0	2	0	5.77
Change In Income	Per-cent	23.96		37.6		52.7		57	

Source: Computed

was relatively low, perhaps at a level which, in the light of whole constellation of uncertainty situations facing the farmers, was hardly of economic significance. However, the income increase in Ashanti and Brong-Ahafo was substantial. It is worth noticing that one of the most successful extension programs in the country, viz the USAID supported Focus and Concentrate Project, was located in areas within the study areas in Volta, Eastern and Central regions. Though the sample farmers did not participate in the program, it is conceivable that they benefited indirectly from the operation of the project.

During the survey, questions were put to the farmers to ascertain the extent of their exposure to extension agents. Fifty-two percent, forty-one percent and fifty-nine percent of the farmers interviewed in Eastern, Volta, and Central region had had some contact with extension agents, whereas the corresponding figures in Ashanti and Brong-Ahafo were 31 percent and 28 percent, respectively.

With respect to Category II farms, in particular, it seems that the application of fertilizers and other chemicals in a mixed-cropping situation was a new experience, as many of the farmers interviewed indicated, and it would require some time to achieve some proficiency in the use of improved practices.

Comparison of Cropping Plans Under Programmed and Actual Conditions

In both categories of farms, it is clear from Tables 5.1 and 5.2 that the need to satisfy family food consumption requirements influenced the programmed cropped plan. In the actual crop plan, all family food requirements were met from own production. The subsistence pattern was repeated in the programmed plan with the exception of Category I farms in Ashanti and in the Volta region, where 84 bunches of plantain and 65 lbs of pepper were respectively purchased from the market. The programmed cropped plans for all the categories would probably have been different if a minimum consumption constraint had not been imposed. Given the choice, the farmers would conceivably prefer meeting consumption requirements from their own resources. Again, the programmed cropped plan would probably have been different if food buying activities had not been introduced into the model. In that case, the objective of the farm would have been the maximization of farm income subject to satisfying basic food requirements or the "security constraint," as Norman terms it. On the whole, the dietetic mix required for subsistence cultivation had a great impact on the programmed crop plan. The fact that the farmers give a high priority to growing crops for home consumption, points to the general acceptance of the changes that emerged in the programmed crop plan.

Average Returns on Resources

In Tables 5.4a and 5.4b, the marginal value products per unit of inputs are given for both categories of farms. Using the MVP of land as an indicator, for Category I farms, it was only in Brong-Ahafo region where land was adequate (i.e., its MVP was zero). In other regions, the MVP of land was high indicating inadequacy of land. For Category II farms, there were two regions--Ashanti and Central--where land was not a limitation. In the other regions, the MVP of land was high, suggesting inadequacy of the resource.

The MVP of capital in the programmed plans of the individual representative farms show that conditions in the five regions differed greatly. For Category I farms, cash expense was found adequate in Eastern, Volta and Central regions. In Brong-Ahafo, the MVP of capital was high, suggesting inadequacy of cash expense. For Category II farms, it was only in Eastern region that cash expense was found to be nonrestricting.

On examination of Tables 5.4a and 5.4b, there is a clear indication of a negative correlation existing between the MVP of land and the MVP of cash expense for all categories of farms, i.e., the higher the MVP of cash expense, the lower the MVP of land. In practice, the decision as to whether to expand a particular resource use can be arrived at by comparing the MVP of that resource with the marginal

factor cost. If the cost per unit of capital, for instance, is less than that of the MVP per unit, it would be profitable to use an additional unit of it. For all the categories of farms and in all regions, we can, on the basis of the above reasoning, expect that all the inputs have high and positive earning power, and their expansion will be profitable. With respect to land, however, the sample results indicated that at least half of the cultivated land was owned as a family land. The official rent charge per acre of land is about ¢1.0. However, in the sample, the average of the "black market" rent charge was in the neighborhood of ¢25.0 an acre. Even if this amount is added to the cost per acre of clearing land (average amortized value of ¢23.8), to reflect the marginal factor cost of an acre of land, the earning power of land would still be very high.

Labor Use

The representative farms in all the regions differed from each other in the extent of their dependence on family labor. The MVPs of labor by periods are given for all the category of farms in Tables 5.4a and 5.4b. By comparing the MVPs of labor given in these tables with the labor selling activities shown in Tables 5.1 and 5.2, there is a clear confirmation of the Johnsonian Asset Fixity Theory at work [Johnson, 1959].

Optimal Solution of Phase II Model

In the previous discussion, it was observed that the magnitudes of the MVPs of labor (in peak periods), land and capital were generally of the level that would offer sufficient inducement for increasing the level of income via increased resource use. Because of the apparent great complementarity between cash availability and resource acquisition (including the clearing or renting of more land), the provision of credit appeared the most important factor for increasing both the size of operation and level of income. As a point of departure from the Phase I model where absolute level of capital (starting cash and borrowing, both of which were constrained) was considered, the Phase II model did not constrain the amount of money that could be borrowed. The Phase II model also allowed cash incomes derived either through the salvaging of family labor or crop sales to relax the cash expense constraint. In addition, land clearing of unused or idle land was allowed to relax the land constraint.

Table 5.5 presents the optimum program for Category I farms in all the five study areas. Comparison of the crop plans presented in Table 5.5 and Table 5.1, indicates that the Phase II model allocated more acreages to the crop enterprises. In Brong-Ahafo, for instance, maize-cassava-plantain-cocoyam-yam mixtures received the largest acreage allocation, 14.7 acres as compared with 6.21 acres as shown

Table 5-5. Characteristics of and Optimal Organizations of Category 1 Farms Phase 2--The Poly-Period Model. Ghana, 1972-73.

	Unit	Brong-Ahafo	Ashanti	Eastern	Central	Volta
Constraints						
Land (Major)	AC	6.7	3.75	2.95	3.5	2.0
Land (Minor)	"	3.0	2.0	2.0	2.5	1.75
Land (Unused Major)	"	3.0	3.0	3.43	3.0	5.0
Land (Unused, Minor	"	2.0	2.0	2.0	2.5	2.0
Starting Cash	¢	125.19	107.8	60.75	103.65	27.0
Labor Period 1	Hrs	845	545	544	795	568
Labor Period 2	Hrs	433	339	343	434	338
Labor Period 3	"	1513	992	1028	1282	901
Labor Period 4	"	468	312	304	398	300
Labor Period 5	"	292	299	257	337	204
Labor Period 6	"	1079	617	602	750	565
Labor Period 7	"	679	562	540	729	539
Annual Labor	"	5298	3666	3619	4725	3395
Activities						
Start Cash	¢	125.19	107.8	60.75	103.65	27.0
Borrow Period 1	"	---	---	30.02	---	110.45
Cash at Hand P. 1	"	49.82	18.24	---	34.43	---
Borrow Period 2	"	343.97	340.2	306.2	259.05	339.04
Cash at Hand P. 2	"	---	---	---	---	---
Borrow Period 3	"	103.86	129.2	100.9	86.44	157.84
Cash at Hand P. 3	"	---	---	---	---	---
Borrow Period 4	"	---	47.6	---	21.28	---
Cash at Hand P. 4	"	24.04	---	---	---	---
Borrow Period 5	"	1.75	25.71	30.58	26.37	---
Borrow Period 6	"	---	---	82.91	---	---
Cash at Hand P. 6	"	1258.4	725.22	---	---	682.44
Clear Land (Major)	AC	3.0	3.0	3.43	3.0	5.0
Clear Land (Minor)	AC	2.0	2.0	2.0	2.0	2.0
Hire Labor P. 2	Hrs	2001	1194	1230	1426	1407
Hire Labor P. 3	"	942	767	579	570	977
Hire Labor P. 4	"	---	540	---	294	---
Hire Labor P. 5	"	---	---	---	---	---
Hire Labor P. 6	"	839	665	757	457	643
Hire Labor P. 7	"	1306	556	680	1198	875
Sell Labor P. 1	"	---	---	163	324	146
Sell Labor P. 2	"	---	---	---	---	---
Sell Labor P. 3	"	---	---	---	---	---
Sell Labor P. 4	"	122	---	81	---	55
Sell Labor P. 5	"	122	163	81	162	73
Sell Labor P. 6	"	---	---	---	---	---
Sell Labor P. 7	"	---	---	---	---	---
Enterprises						
Maize (Minor)	AC	5.0		4.0		3.75
MV	"		4.0		5.0	
MOYV	"	.10				
MCOY	"					.02
MCOYV	"					
MCPOY	"	9.6		6.3		6.98
MPOYV	"		6.7			
MCPOYV	"			.02	6.58	
Gross Revenue	¢	4175.84	2913.33	2903.16	3327.7	3339.64
Total Acres	AC	14.73	10.7	10.32	11.58	10.75
Gross Revenue/Acre	¢	283.49	272.28	281.32	287.37	310.66
Return/Hour	¢	.40	.39	.46	.38	.46
Return/Capital	¢	7.26	4.48	4.76	6.26	5.26
Labor Hours/Acre	¢	705	690	665	749	679
Amount Borrowed/Acre	¢	30.52	50.73	53.27	36.92	56.5
Ratio of hired labor to total labor input	%	48.98	50.38	47.28	45.5	53.47

Source: Computed

Legend
Labor P. 1 = Labor Period 1.
AC = Acre
¢ = Cedis (currency)
Hrs = Hours

in Table 5.1. In addition to changes in the cropping plans and acreages when compared with the Phase I model, there were increases in the gross income accruing from the optimal programs. The gross revenue from the optimal program for the Category I farms in Brong-Ahafo was ¢4175.84 (or ¢175 increase over the gross income in Phase I). Pairwise comparison of the optimum gross income between the two phases for the other regions are: ¢2913.3 (or 123 percent increase) in the Ashanti region; ¢2903.16 (or an increase of 55 percent) in the Eastern region; ¢3327.7 (or an increase of 82 percent) in the Central region; and ¢3339.64 (or an increase of 202 percent) in the Volta region. However, the gross return per acre, gross return per man-hour and the gross return per cash expense were lower than the solutions obtained in the Phase I model (Table 5.1). The degree of complementarity between cash expenses and other resources is illustrated by the following economic measures given in Tables 5.5 and 5.1: the amount of borrowed money per acre and the ratio of hired labor to total labor inputs. The figures suggest a high correlation between the two measures. The implication is that the more cash made available, the more the complementary resources that could be bought.

The crop plans for Category II farms are given in Appendix Tables B.1a to B.4a. (Discussion in this section is limited to Column 2A in the tables.) The crop plans resulted in a gross income of ¢9301.01, ¢5900.84, ¢4051.77

and ¢4675.45, respectively for the Category II farms in Brong-Ahafo, Ashanti, Eastern and Central regions. These figures represented income gains of 84 percent (Brong-Ahafo), 185 percent (Ashanti), 131 percent (Eastern region) and 52 percent (Central region) over those obtained in Phase I. The crop plan in all the representative farms were diversified with more land being brought into cultivation. In all the representative farms, an examination of Appendix Table B.1a shows that maize, grown in pure-stand on major season land proved to be the least competitive enterprise. This point is brought home by the magnitudes of the shadow prices associated with major season maize (Tables B.1b, B.2b, B.3b and B.4b).

In Table B.1b, as an example, coclumn names; SMZ4 (sell maize in period 4) and MZTR4 (maize output transfer from period 4 to 5) through column TVEG6 (vegetable output transfer from period 6 to period 7) and SVEG7(vegetable selling in period 7), outline the stages involved in the on-farm storage activities which were incorporated into the Phase II model. In each period, there was a beginning inventory which successively underwent attrition through sales, consumption withdrawals and losses through spoilage. In the Brong-Ahafo region, for instance, period 4 began with a maize inventory level of 119.504 bags.[4] Out of this

[4]The storage activities begun in period 4 for maize and pepper and period 6 for yam and cocoyam. The harvesting of the crops, as explained earlier, took place in these periods.

amount, .167 unit was withdrawn for home consumption and allowing 2.27 percent loss through diseases, damages, water losses and rodent attacks, an amount of 116.11 bags was stored for the next period (period 5), and the process continued. No maize selling activity took place in period 5 as it was considered to be ¢3.205 more expensive to do so. Only if the selling price of maize in period 5 (which was ¢5.03) had risen to at least ¢8.24 would it have been profitable to sell in this period.

Comparison of Optimal Organization and Income With Actual Organization and Income by Region and by Category

Phase II has six distinct features: 1) allowing borrowing up to the maximum level, determined by the program with no constraint imposed on it whatsoever; 2) allowing the clearing of unused land up to the limits observed for the sample; 3) incorporating food consumption on seasonal basis, thus allowing food purchasing to take place during pre-harvesting periods so as to satisfy the minimum consumption constraint; 4) allowing interdependence of production, consumption and investment to take place so that a stream of money income from crop sale and the salvaging of family labor could be fed into the system to relax the seasonal cash availability constraint; 5) introducing storage activities so that the model would determine the most profitable period to effect crop sales; and 6) introducing cash flows to allow the model not only to determine optimum borrowings based on

the cash expense requirements of a particular period, but also to facilitate the transfer of idle cash from one period to the next. These features allow the model to approximate more closely the actual behavior of the farm household under subsistence agriculture.

Category I Farms

Table 5.6 contains paired comparison of the programmed income and organization on one hand and the actual income and organization, as observed in the sample, on the other. In all the regions, all the available land was brought into cultivation including hitherto idle land, which was cleared to relax the land constraint. Other important features of the programmed organization were large increases in borrowings and amount of labor hired. The increase in gross income over the actual ranged from 246 percent in Brong-Ahafo to 106.0 percent in Eastern region. Most of the income increase resulted, among other things, from more land being brought into cultivation. This was made possible by the timely availability of cash through borrowings.

Category II Farms

Table 5.7 contains a comparison of programmed income and organization with the actual. Again, the programmed results confirm the existence of complementarity between cash availability and size of farm measured by acreage. The results also portray the dependence of the farm on both

Table 5.6. Comparison of Phase II Results with Observed Sample Data Category I Farms by Region.

ITEM	UNIT	BRONG-AHAFO		R E G I O N ASHANTI		EASTERN		VOLTA		CENTRAL	
		Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis	4175	1206.4	2913.33	960.1	2903.16	1403.4	3339.64	826.9	3327.7	1442
Family Labor	Hrs	5298	5776	3666	3675	3619	4334	3395	3571	4725	4823
Hired Labor	Cedis	5087	2064	3722	384	3246	95	3902	48.0	3945	558
Cash Expense	Cedis	125.19	125.19	107.8	107.8	60.75	60.75	27.0	27.0	103.65	103.65
Borrowed Capital	Acre	449.53		542.77	86.25	549.72	74.25	434.92	56.25	352.16	91.19
Acreage (Major Season)	Acre	6.7	6.7	3.75	3.75	2.95	2.95	2.0	2.0	3.5	3.5
Acreage (Minor Season)	Acre	3.0	3.0	2	3.0	2.0	2.0	1.75	1.75	2.5	2.5
Unused Land Cleared (Maj)	Acre	3.0	3.0	3	3	3.43	3.43	5	5	3.0	3.0
Unused Land Cleared	Acre	2	2	2	2	2.0	2.0	2	2	2.5	2.5
Change In Income	%	246		203		106.0		304		130	

Source: Computed

Table 5.7. Comparison of Phase II Results with Observed Sample Data, Category II Farms by Region.

ITEM	UNIT	R E G I O N							
		CENTRAL		EASTERN		ASHANTI		BRONG-AHAFO	
		Programmed Income	Actual Income	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis	4675.45	1636.5	4051.77	1934.7	5900.84	1354	9310.01	3225
Family Labor	Hrs	3178	3178	4429	4450	4050	4219	7675	8492
Hired Labor	"	13532	215	1927	126	9647	432	14772	2264
Cash Expenses	Cedis	74.61	74.61	125.02	125.02	125.19	125.19	250	250
Borrowed Capital	Acres	582.86	104.55	377.8	85.79	1219.43	123	1580.89	346
Acreage (Major Season)	"	4.97	4.97	3.22	3.22	6.2	6.2	17.3	17.4
Acreage (Minor Season)	"	2.0	2.0	2.5	2.5	2.0	2.0	5.77	5.77
Unused Land (Major)	"	3.51	3.51	4.0	4.0	6.0	6.0	4.0	4.0
Unused Land (Minor)	"	2.0	2.0	0	2	0	2.0	4.0	4.0
Change In Income	%	186		109		336		188	

Source: Computed

family labor and hired labor, the latter made available because of increased borrowings. The income gain ranged from 109 percent in the Eastern region to 336 percent in Ashanti region. A comparison of the cropping plans under the optimum (Appendix Tables B.1b, B.2b, B.3b and B.4b) and the actual situation (Table 3.4) show that the optimum plan allocated few profitable enterprises, suggesting some specialization enterprise-wise, not crop-wise as we will expect the situation to be. Yam is not only a high yielding crop, but is the most profitable crop to raise. In fact, in the study areas in Ashanti and Brong-Ahafo, it is the most important crop. Thus, we find 21.34 acres allocated to maize-cocoyam-yam-vegetable enterprise in Brong-Ahafo and 12.0 acres to maize-cassava-plantain-cocoyam-yam enterprise in Ashanti. The optimum plan in all regions excluded pure-stand maize in the major season, the shadow prices associated with it being ¢371.8, ¢419.9, ¢507.3 and ¢454.58 for Brong-Ahafo, Ashanti, Eastern and Central regions respectively. However, pure-stand maize in the minor season received the following allocations: 9.77 acres in Brong-Ahafo, 4.0 acres in Central region and 2.0 acres in Ashanti. It is rather surprising, the minor season land in the Eastern region was left unused in the optimum plan. Cash expense availability was not the reason since ¢349.1 cash was available in period 5--the period to commence operations on minor season land. The MVP per unit of family labor was zero in

period 5 and labor hiring per unit in that period was ¢.10 too expensive. Thus, the program chose to salvage family labor instead of commit it to crop production.

Regional Comparison of Farm Organizations by Category

Table 5.5 presents the optimum incomes and farm organizations for Category I farms in all the study areas. The gross revenue per acre ranged from ¢310.66 in Volta region to ¢272.28 in Ashanti region. The gross income figures are net of the starting money capital and the principal of borrowed money.

There was a marked increase in the acreage cultivated. All land, including hitherto idle land being brought into cultivation. On further examination of Table 5.5, it becomes obvious that the dependence of the farms on hired labor increased as compared with the Phase I situation. The ratio of hired labor to total labor inputs ranged from 45.5 percent in Central region to 53.47 in Volta region. The average return per unit of capital was above the cost of procuring one unit of it. In all the regions also, the average return per unit of labor input was high in comparison with the cost of hiring one unit of labor.

Enterprise specialization is indicated by the fewer enterprises in the optimum plan as compared with the initial situation. Minor season maize in pure-stand received substantial acreage allocation in Brong-Ahafo region (five acres), in Eastern region (four acres) and in Volta region (3.74 acres).

Appendix Tables B.1a to B.4b contain the optimum solutions for Category II farms. The gross monetary return per acre ranged from ¢415.55 in Ashanti to ¢300.23 in Brong-Ahafo region. The largest farms, however, were Brong-Ahafo (31.07 acres), followed by Ashanti (14.2 acres), Central region (12.48 acres) and Eastern region (9.224 acres). The dependence of the farms on hired labor is evidenced by the ratio of hired labor to total labor inputs--65.81 percent, 70.43 percent, 30 percent and 52.64 percent in Brong-Ahafo, Ashanti, Eastern and Central regions, respectively. The figures showing the amount of money borrowed per acre are high, far exceeding the institutional limit of ¢15.00 imposed by the Agricultural Development Bank for loans to small farmers. The average returns per unit of capital and per unit of labor are rather high, far exceeding the opportunity cost of borrowing (¢01.06) and the average wage rates which varied from region to region.

Maize, as a pure-stand enterprise, did not appear in the optimum plan in all the regions. The shadow prices associated with it were ¢371.8, ¢419.9, ¢507.3 and ¢454.58, respectively, for Brong-Ahafo, Ashanti, Eastern and Central regions. The figures indicate the extent to which this crop enterprise is too expensive to be included in the optimum program. Generally, in the Phase II model, profitability of cropping enterprises, rather than subsistence requirements or security considerations, had a major impact on the cropping plans that emerged.

Comparison of Income, Marginal Value Products and Average Returns by Region and Category

On examination of Table 5.5 and Appendix Tables B.1a, B.2a, B.3a and B.4a, it is evident that the returns per acre are higher for the Category II farms than the corresponding figures for Category I farms. For the two categories of farms in Brong-Ahafo, Ashanti, Eastern and Central regions, the difference in gross returns per acre were ¢16.74, ¢143.0, ¢156.94 and ¢63.98, respectively. The relatively lower gross return per acre for the Category II farm in Brong-Ahafo is quite understandable when viewed from the fact that an acreage of 31.07 perhaps is too much for efficient management under existing technology of production. This explanation is only conjectural; there may be other reasons to account for the phenomenon. However, it is noteworthy that the gross return figures for the Category II farms are higher than those for Category I farms.

The ratio of hired labor to total labor inputs in Category II farmers in Brong-Ahafo and Ashanti were higher (65.81 percent and 70.43 percent, respectively) than the corresponding data for Category I farms in the regions, both sets of categories of farms, however, exhibit a heavy reliance on hired labor. There is also an appreciable reliance on hired labor in Eastern and Volta regions.

The marginal value products (in cedis per unit of a resource) are given in Table 5.8 by region and for both categories. In Tables 5.4a and 5.4b, it was observed that

Table 5.8. MVPs of Resource of Category I and Category II Farms--Phase II by Region (Cedis).

RESOURCE	UNIT	REGION									
		ASHANTI		BRONG-AHAFO		EASTERN		CENTRAL		VOLTA	INPUT PRICE
		Cat. I	Cat. II	Cat. I	Cat. II	Cat. I	Cat. II	Cat. I	Cat. II	Category I	
Starting Cash	Cedis	.051	.06	.051	.051	.06	.051	.051	.06	.06	.06
Land (Major)	Acres	362.76	446.76	398.7	423.1	4.35	529.7	376.6	513.34	449.6	Not Given
Land (Minor)	"	62.49	85.23	15.4	39.8	56.99	62.7	89.1	488.1	424.39	"
Cleared unused Land (Major)	"	337.73	421.5	373.7	398.0	409.7	504.7	351.6	488.1	424.39	"
Cleared unused Land (Minor)	"	50.29	0	3.2	27.56	44.8	0	87.52	39.97	28.76	"
Planting Materials											
Maize	165	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06
Cassava	100	-17.01	2.63	2.63	-33.9	2.63	2.63	2.63	2.63	2.63	2.5
Plantain	Unit	.06	.06	.0001	.06	.06	.06	.06	.06	.06	.06
Cocoyam	100	3.15	3.15	3.15	3.15	3.15	3.15	3.15	-327.0#	3.15	3.
Yam	100	5.25	5.25	5.27	5.27	5.25	5.25	5.25	5.26	5.26	5.0
Pepper	lb.	.53	.53	.53	.53	.53	.53	.53	.53	.53	.5
Other Inputs											
Fertilizers	Bag		2.94	Nil	2.94		2.94	Nil	2.94	Nil	2.8
Matchetes	Single	.88	.88	.88	.88	.88	.88	.88	.88	.88	.88
Hoes	"	.41	.41	.41	.41	.41	.41	.41	.41	.41	.39
Axes	"	.83	.83	.83	.83	.83	.83	.83	.83	.83	.79
Chissels	"	.33	.33	.33	.33	.33	.34	.34	.33	.33	.32
Baskets	"	.32	.32	.32	.32	.32	.32	.32	.32	.32	.30
Labor By Periods											
Period 1	Hour	.06	.18	0	.139	0	.16	0	.16	.09	Variable
Period 2	"	.15	.15	.12	.119	.15	.149	.10	.15	.15	"
Period 3	"	.17	.17	.12	.118	.17	.063	.11	.06	.17	"
Period 4	"	.15	.14	0	.127	0	.06	.10	.15	.06	"
Period 5	"	0	0	0	0	0	0	0	.06	0	"
Period 6	"	.14	.14	.10	.104	.15	.142	.18	.14	.14	"
Period 7	"	.14	.14	.10	0	.14	.06	.15	.14	.14	"

Source: Computed

Legend: Cat. I: Category 1 Farms
Cat. II: Category 2 Farms

for most of the resources, the ratios of marginal returns to marginal factor costs were high, indicating that some adjustment towards the optimum (i.e., where MVP/MFC = 1) would be profitable. The ratio of MVP and MFC for cash expense for Category II farms in Ashanti and Central region and for Category I farms in Eastern region was estimated to be equal to one, suggesting that money capital was being optimally used--and that no further adjustment was needed. On examination of Tables B.1a, B.2a, B.3a and B.4a, it can be seen, going down the column containing MVPs of cash at hand by period, that the MVPs declined until they became zero. In each period, however, the ratio of the MVP to the interest charged approximated unity, suggesting the resource was being used optimally.

An examination of the MVPs of labor for all categories indicates that there were few periods during which family labor was in slack, suggesting greater labor utilization as farm size expands (compare with corresponding figures in Tables 5.4a and 5.4b).[5]

Perhaps the greatest indication of resource efficiency can be found by examining marginal value products of inputs (planting materials and other inputs) given in Table 5.8.

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[5]The marginal conditions for allocative efficiency implied in this section of the discussion have relevance within a set of constraints and objective functions specified for a given LP model only. The erratic nature of the MVP's limits their application as pointers to allocative efficiency of resource.

The relevant input prices are given in the column labeled "input price." With the exception of cassava sticks in Category I farms in Ashanti and Category II farms in Brong-Ahafo, and also cocoyam tubers in Central region, the ratios of MVP to MFCs approximated unity. It is interesting to note that the crop mix enterprises in the optimum solutions did not include cassava in Ashanti and Brong-Ahafo and cocoyam in Central region. The MVPs of the planting materials associated with these outputs are, therefore, shown in Table 5.8 to be negative, suggesting that one more unit each of the input added to the plan will diminish income by the amounts indicated by the size of the negative marginal value products.

Programmed Income: Category II Farms, Phase III

The programming results given in the previous two phases do point to the apparent superiority of mixed-cropping over pure-stand cropping. In the two phases mentioned, only those cropping activities were considered which were actually practiced by the farmers of the sample of 1972-73. The coefficients used were those derived from average sample data for each representative farm.

Adoption of improved technology appears a prerequisite to the success of output increasing programs.[6] In the Phase

[6]This is a hypothetical statement not empirically tested in this study.

III of the poly-period model, pure-stand cropping enterprises, using improved technology, were introduced as parallel activities to the historical cropping enterprises in Phases I and II. This aspect of the study was meant to answer one important question, viz. could cropping enterprises, using improved technology, effectively compete with enterprises using indigenous technology. The Phase III model was thus used to provide some answers to the above mentioned question by assessing, 1) the potential contribution of improved technology to the level of income through expansion of farm size and, 2) the competitive position of the crops produced under the improved technology in the study area. The first improved technology was one involving use of improved planting materials, the use of improved cultural practices and the substitution of custom-hired machinery for plowing and harrowing the land. A second improved technology added to the first, the use of a less labor intensive means of weeding, i.e., by application of weedicide. Thus, two different methods of producing a single pure-stand crop such as maize were considered in the model.[7] These two alternatives applied only to the improved cropping activities that were added to the Phase II model.

The programmed results for Category II farms are shown

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[7]These are referred to in the Phase III model as technologies 1 and 2.

in Table 5.6, column labeled 3A. They are discussed on a region by region basis in the following sections.[8]

Brong-Ahafo Region

For Category II farms, the gross income was ¢9349.01 representing a ¢31.0 increase over Phase II. The total labor inputs in Phase III amounted to a gross figure of 14,372 hours, 400 hours less than the corresponding labor inputs in Phase II. However, ¢85.11 more cash expenses, representing additional borrowings, were incurred.

The Phase III model allocated 21.34 acres to the maize-cocoyam-yam-pepper mixtures and 9.77 acres to MZNA1 (i.e., maize production in the minor season using recommended practices, but no weedicides). The answer to the question as to how compteitive the crop enterprises, using improved technolcgy, are can be found by examining the cropping activities that entered the solution and the shadow prices of the excluded activities. The shadow prices are shown in Appendix Table B.1 under the column labeled π. In Table B.1b, it is clear that advanced technology improves very little the competitive position of maize grown as pure-stand on a major season land. Use of MZA3 (i.e.,

[8]Category I or indigenous farms were excluded in this analysis. The intent is to show what the optimal income or plans of Category II (transitional) farms would be if they adopted recommended practices.

advanced technology of producing maize in pure-stand on major season land) is even less. The shadow prices associated with this cropping enterprise is ¢497.8. A glance through the shadow prices of the excluded enterprises further establishes the dominance of mixed cropping over pure-stand cropping under advanced technology.

Ashanti Region

At the bottom of Table B.2b, the enterprises which did enter the solution are given. The plan allocated 5.48 acres to maize-plantain-cocoyam-yam mixtures, two acres to minor maize produced in pure-stand under the transitional technology and 6.7 acres to YAMA1 (yams produced in pure-stand using improved technology alternative 1).

The optimum income obtained in Phase III for this category of farms was ¢5946 representing an income gain of ¢45.0 as compared with the corresponding income in Phase II. As shown at the bottom of Table B.2a, the returns per unit of cash expense used and per man-hour of labor (¢5.59 and ¢0.66, respectively) were a marked improvement over the corresponding figures in Phase II (column 2A). The plan also used less labor hours per acre (626 as compared with 965 in the Phase II) with the ratio of hired labor to the total labor input falling to 55.92 percent. The slack associated with the annual family labor available (LABRAN) was 214 hours as compared with 84 hours in Phase II. A total of 588 hours of family labor were sold. The MVPs

of capital (CASHP) and seasonal labor (LABRP) in both situations were virtually the same. In terms of returns per acre, per man hour of labor capital and labor use per acre, the Phase III model proved superior to the Phase II model, but it is worthy of notice that the crop plan that emerged was a combination of enterprises using both "transitional" and advanced technology.

Eastern Region

The cropping plan evolved and was diversified with 7.18 acres allocated to maize-cassava-cocoyam-yam enterprise, .04 acre to maize-cassava-plantain-cocoyam-yam enterprise, and 2.0 acres to minor season maize (MZNA1) produced using advanced technology alternative 1.

The optimum income was ¢4059.7, representing a gain of only ¢7.63. In the two phases, when compared, the returns per unit of money capital was about the same. However, labor inputs per acre and return per unit of cash expense were slightly higher in Phase III. Labor was more efficiently used in Phase III than in Phase II.

Central Region

The cropping plan allocated 4.0 acres to MZNA1 (minor season maize in pure-stand using advanced technology 1); 4.0 acres to minor season maize under the "transitional" technology and 8.48 acres to maize-cassava-yam enterprise. The shadow prices given at the bottom of Table B.3b indicate that plantains, PLATA1 and PLATA2, produced using the

improved technology could be forced into the plan at zero opportunity cost. Considering the fact that in the real world, plantains are never grown as sole crops, the crop could be forced into at less than the shadow price indicated if some cocoyams, normally intercropped with plantain, are mixed with the plantain enterprise.

The optimum income is Phase III was ¢4697.82, an increase of ¢22.37 over the optimum income in Phase II. The average return per unit of labor was ¢0.72 compared with ¢0.70 in Phase II. The Phase III plan also used less labor hours per acre (519 hours) as compared with the amount of 538 hours used per acre in Phase II.

Regional Comparison of Results of Phase III with Observed Sample Data: Category II Farms

The optimum income and organization of the Phase III model are compared with the data from the observed sample situation in Table 5.9.

The highest percentage income gain was in Ashanti. The source of the high income gain was the allocation of 6.7 acres to yams produced using alternative technology 1. Though the optimum plan allocated 548 acres to maize-plantain-cocoyam-yam enterprise and 2.0 acres to maize-pepper enterprise in the minor season, it can be said that as compared with the actual crop plan, the optimum crop plan was diversified with fewer enterprises. Eight acres of idle land was cleared and brought into cultivation. The

Table 5.9. Comparison of Phase III Results with Observed Sample Data, Category II Farms.

Item	Unit	Region							
		Central		Eastern		Ashanti		Brong-Ahafo	
		Programmed	Actual	Programmed	Actual	Programmed	Actual	Programmed	Actual
Gross Income	Cedis	4697.82	1636.5	4059.4	1934.7	5946	1354	9349.01	3225
Family Labor	Hour	3024	3178	4349	4450	3920	4219	7274	8492
Hired Labor	"	3459	215	1839	126	4972	432	14372	2264
Cash Expenses	Cedis	74.61	74.61	125.02	125.02	125.19	125.19	250.0	250
Borrowed Capital	"	376.43	104.55	368.9	85.79	937.06	123	1666.6	346
Acreage (Major Season)	Acre	4.97	4.97	3.22	3.22	6.2	6.2	17.3	17.3
Acreage (Minor Season)	Acre	2.0	2.0	2.0	2.5	2.0	2.0	5.77	5.77
Unused land (Major)	"	3.51	3.51	4.0	4.0	6.0	6.0	4.0	4.0
Unused Land (Minor)	"	2.0	2.0	0	2.0	0	2.0	4.0	4.0
Change in Income	%	187		110		339		190	
Gross Income Per Acre	Cedis	127.9		165.02		418.43	165	159.7	

Source: Computed.

increased cash expense through unlimited borrowing was a factor in making it possible to acquire more labor inputs and bring more land into cultivation.

In all the other regions, the same pattern of resource increase in the optimum plan can be observed. In the Eastern region, the income gain was only 110 percent. This is relatively less than comparative percentage increase in other regions. A possible explanation is that the Category II farms in the Eastern region were operating closer to the optimum than the farms in the other regions.

Regional Comparison of the Impact of Technology on On Income, Employment and Farm Organization

The main purpose of Phase III was to determine what the optimum farm organization would be and what income and other relevant measures would be if the representative farmers adopted certain recommended practices. By introducing a labor-saving technology of cropping as an alternative, it was expected that the optimum organization will enlighten us about the employment effect of introducing the technology into farming in the new areas.

The following cropping plans emerged for the farms in the regions (Table 5.10).

It is important to note that none of technology 2 type crop enterprises entered the solution in all the regions. In Central region, a price per bag of herbicide of ¢3.4 would have been needed to make it profitable for PLATA2 (plantain

Table 5.10. Phase III Cropping Plan.

Enterprise	Unit	Region			
		Ashanti	Brong-Ahafo	Eastern	Central
Maize-Plantain-Cocoyam-Yam	Acre	5.48			
Maize-Vegetable (Minor Season)	Acre	2.0			
Yam (Technology 1)	Acre	6.7*			
Maize-Cassava-Yam	Acre				84.8
Maize (Minor Season Technology 1)	Acre				4*
Maize-Cassava-Cocoyam-Yam	Acre			7.18	
Maize (Minor Season Technology 1)	Acre			2.0*	
Maize-Cocoyam-Yam-Vegetable	Acre		21.34		
Maize (Minor Season Technology 1)	Acre		9.77*		

*Using improved technology of production.

enterprise using technology 2) to enter an alternative optimum plan. In the Eastern region, a price per bag of weedicide of ¢2.6 would have made it profitable for minor season maize enterprise, using technology 2, to have entered an alternative optimum plan. In Brong-Ahafo region, a price of ¢2.2 was required to make it remunerative for pepper enterprise using technology 2 to have come into an alternative optimum solution. In Ashanti region, however, the optimum plan was more

sensitive to weedicide price changes than was the case in the other regions. A price of ¢4.76 would have brought in yam production using technology 2. In the absence of technology 2, cropping enterprises in any of the optimum plans the model has not proved helpful in enabling us to evaluate fully the effect this type of labor-saving technology on farm organization. To asses the employment effect, we shall compare the Phase III results with the Phase II results.

In Ashanti region, 8,892 units of labor were purchased as against 13,697 in Phase II. Yam enterprise is a labor consuming enterprise using transitional technology. The allocation of 6.7 acres to yam enterprise using technology 1 partly explains this reduction in labor. The difference is significant, as in aggregate the farm in the two situations had 14.2 acres under cultivation. In Eastern region, labor hours used per acre in Phase III were 671 as against 689 in Phase II. The small difference can be explained by the fact that only 2.0 acres of minor season maize enterprise using technology 1 was allocated. In the Central region, the difference was only 19 hours, hardly of significance. Similarly, in Brong-Ahafo region, the difference was 25 hours.

In making inter-regional comparison of return per acre, the following pattern emerges also: 1) in Ashanti, the return per acre amounted to ¢418.3 as against ¢415.55 in Phase II; 2) in Eastern region, the return per acre was ¢440.09 as against ¢439.26; 3) in Central region, the respective figures

were ¢376.43 per acre in Phase III and ¢374.04 per acre in Phase II and 4) in Brong-Ahafo region, the corresponding figures were ¢300.90 per acre in Phase III and ¢300.23 per acre in Phase II. Of the four regions, the income per acre ranged from ¢300.90 per acre in Brong-Ahafo to ¢440.09 per acre.

The results so far indicate that while return per acre, per unit of capital and per unit of labor are higher in Phase III situation; the use of recommended technology did not make a major impact on output, employment and income. The question often raised is whether pure-stand crop enterprises using improved technology can compete with mixed-crop enterprises using transitional or indigenous technology. The obvious answer is that with the exception of maize in the minor season throughout the study areas and yam in Ashanti region, pure-stand crop enterprises using advanced technology hold a weak competitive position.

Concluding Remarks

The empirical findings in this chapter are of value in suggesting economic adjustments in resource use and policies designed to promote efficient agricultural production in the study areas. A description of the inter-region and inter-category difference in resource productivity given attention in this chapter is helpful in explaining the nature and extent of forces which influence the pattern of resource allocation and cropping plans. Such knowledge will enable policy makers

to examine these forces to improve agricultural policy with respect to: 1) which resources to encourage its expansion and, 2) in what area and in what category of farms it is profitable to do so. The rest of this section will summarize the most significant policy-related findings in the chapter.

Summary of Phase I Results

The results indicate a substantial potentiality of increasing farm income and production with existing resource supplies and the present technical knowledge of the farmers.

Category II Farms

With respect to Category II farms inter-area comparison of MVPs shows that land is inadequate in Brong-Ahafo and Eastern regions. Cash expense is also found inadequate in Ashanti and Central regions. The MVP per unit of money capital in Ashanti (¢1.81) was slightly over its opportunity cost (¢1.06). For all the inputs, except labor, the MVPs per unit are substantially above their respective opportunity cost (marginal factor cost), indicating that further adjustment would be required to maximize income.

With regards to labor, periods 2 and 7 prove to be the periods labor is inadequate in all the regions. There are, however, minor regional variations. In Brong-Ahafo, labor tends to be limiting in all the periods, whereas in Central period 4 proves to be a peak demand period.

The results further demonstrate that with exception of Brong-Ahafo (with 63.8 percent of total labor inputs

coming from hired sources), there is a great reliance on family labor. With the MVP per unit of labor equal to zero during most of the periods (farm seasons), the farmers ought to be more inclined toward maximizing returns per acre rather than attempt to equate MVP per unit of labor to the hired wage rate.

Category I Farms

Generally, the peak period of labor use is in period 2 when labor is intensively used for land preparation and planting. However, in Ashanti, labor in period 6 also proves to be limiting, as expected, as it is the period labor is intensively used for yam harvesting. In Brong-Ahafo, period 4 also proves to be a period when labor is inadequate.

Inter-area comparison of marginal value products of land shows land to be very limiting in all the regions except Brong-Ahafo region (Table 5.4a). However, whereas cash expense is a limiting factor in Brong-Ahafo, it is less so in the other regions.

Comparison of MVPs per unit of the variable inputs other than labor shows that in Central region these MVPs per unit are approximately equal to their respective marginal factor costs. In the other regions, however, the MVPs are shown to be greater than the marginal factor costs indicating that further adjustment via unit increases of the inputs would prove profitable.

Cropping--General

Within the framework of optimum cropping program, the programming results show that for all categories of farms and in all regions, mixed-cropping enterprises produced using indigenous or transitional technology are in a stronger competitive position than pure-stand crops. Maize as a pure-stand crop in the major season does not enter any optimum programs.

Relevance of Subsistence Food Requirements

Despite the introduction of food buying activities into the Phase I model, the results show that the dietetic mix required by subsistence agriculture has influenced the cropping plans in the optimum programs. The only striking difference occurs in Ashanti and Central regions where a few food purchases can be observed (Table 5.1).

Comparison of Optimum Plans with Actual

In general, the programmed crop plans are shown to be diversified with fewer crop enterprises than what the observed sample data show. The most striking observation is the absence of major season maize in pure-stand in the programmed plans.

With respect to Category I farms, the gross income increase ranges from 26 percent in the Central region to 49 percent in Brong-Ahafo region. In the light of the presence of elements of risk and uncertainty which the

farmers might have taken into consideration in the actual situation, but were not considered in the model, it can be said that the farmers appear to be operating close to the optimum in the Central, Eastern and Volta regions.

The divergence of income between the actual and programmed with respect to Category II farms approximates that observed in Category I farms in Eastern and Central regions. A bigger income difference can be observed for Category II farms in Ashanti and Brong-Ahafo. We have observed that this situation can be explained, among other things, by the fact that the application of fertilizers and other chemicals on mixed-cropped farms appear to be a new experience, as many of the farmers indicated during the survey, and it will require some time before they achieve some proficiency in the use of the new techniques of production.

Summary of Phase II Results

It was observed in the Phase I model that on account of the existence of great complementarity between cash expense availability and other resource acquisition as aid in production, the provision of credit to the farmers in the right amounts and in the appropriate time appears as the most important factor in increasing income and production through size expansion. We shall summarize the main effects of credit expansion.

Inter-area Comparison of MVPs

It can be seen in Table 5.8 that with cash use pushed to it optimum period-wise as dictated by the requirements of both consumption and farm operations, the MVP per unit of cash expense has become approximately equal to the margional factor cost. Major season land which in Phase I was shown to be adequate in some regions and inadequate in others is seen to be a limiting in the Phase II model.

For all other mobile inputs, other than labor, the results in Table 5.8 indicate that the MVPs per unit of each resource is approximately equal to the marginal factor cost. The results are interesting as they do show that farmers in these areas are rational and can achieve allocative efficiency of resource use if the main bottleneck is removed.[9] It is evident from the results obtained here that the question is not merely giving credit to the farmers. Rather, the timing of the credit is important; so also is the optimum amounts determined not only by production requirements, but consumption needs as well.

Labor Use

With the expansion of resources via more land cleared and brought into cultivation and also via increased cash expense, labor became limiting. Thus, the MVPs per

[9] For example, within a given set of restrictive, activities and objective coefficients.

unit of labor are not only high for most of the periods, but remarkably above their respective marginal factor cost. With more cash expense made available, the total hired labor inputs increased for all the categories of farms.

Average Return Per Resource

For all the categories and in all regions, the average returns per acre, per unit of capital and per unit of labor are shown to be above their respective opportunity cost. As compared with the corresponding situations in Phase I, labor use per acre in Phase II is lower indicating relative labor use efficiency.

Crop Plans

Almost all available land (including hitherto unused land) is brought into cultivation. The optimum crop plan shows greater enterprise diversification, with fewer enterprises, but greater acreage allocation. As compared with the actual crop plan, major season maize in pure-stand is eliminated because as shown by the magnitude of its various shadow prices, it is in a weak competitive position vis-a-vis crop mixtures.

Subsistence or Security Requirements

As compared with the Phase I model, subsistence food requirements do not appear to influence the programmed crop plan. The dynamic interdependence between production, consumption and investment is clearly demonstrated in the Phase

II model. The food storage and inventory carry-over sub-model influenced the profit maximizing decision of the farmers.

Income Gains

As compared with the Phase I model and the observed sample data, the summaries in Tables 5.6 and 5.7 indicate that the income gains in this phase are relatively higher. As expected, however, the average returns per acre, per unit of labor and per unit of capital declined relatively.

Summary of Phase III Results

The results show that while average returns per acre, per unit of capital and per unit of labor are slightly higher in Phase III than they were in Phase II, the application of improved technology, within the present institutional arrangements have not made a major impact on output, employment and income. Within the general framework of an optimum cropping program, the results demonstrate that in the major season, mixed-cropping using indigenous technology and transitional technology are more competitive than pure-stand crops using improved technology. A striking exception is pure-stand yam in Ashanti and minor season maize in the regions, all of which use advanced technology.

CHAPTER VI

EFFECTS OF RESOURCE EXPANSION ON INCOME AND FARM ORGANIZATION

The previous chapter was devoted to summarizing and discussing the programming results of the LP model in three empirical phases. In Phase I, farm organization was discussed in the context of existing resource supplies and technique of production. Resources of land, cash expense, borrowing and labor were treated as fixed. By introducing labor hiring activities into the model we, in effect, relaxed the restriction on labor supply and made land and capital a more limiting restriction.[1] Thus, the optimum plans in the sample using the Phase I model were governed by two most limiting resources--land and money capital. The linear programming results provided a measure of the earning power of additional units of these resources. Thus, the profitability of acquiring

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[1]Since borrowing activity formed part of the model, it also served to relax the cash expense restriction. But there is a difference here. Borrowing was limited by the amount indicated by the institutionally fixed level of ¢15 per acre. Thus, the relaxation of cash expense constraint through borrowing was confined to certain limits and made the borrowing activity not very effective in relaxing the cash contraint.

more of the resources was indicated by the magnitudes of the marginal value products.[2] The analysis also provided information on the potentials for increasing incomes by expanding resource use.

In Phase II--the poly-periodmodel--the constraint on borrowing was eliminated, thus in effect, making land a more restircting resource. The model was allowed to determine the optimum amount of borrowing.

In this chapter, we shall be examining the effect on farm organization and income of resource expansion. Seven situations will be examined for Category II farms in the static linear programming phase, viz; 1) no change in the initial resource situation presented in Chapter V; 2) additional land clearing of owned or rented unused lands up to the limit observed in the sample (see Table 5.6b); 3) deletion of overhead labor and the conversion of labor hiring coefficient from .66 to 1.0;[3] 4) 30 percent increase

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[2]The MVPs of Category II farms for Central and Ashanti regions were low, indicating that land was adequate on these representative farms. These two categories proved an exception to the observation made in the text.

[3]Since the overhead labor includes labor for the maintenance of bush fallow and the harvesting of bush fallow crops, its deletion here would appear to wipe away the opportunity. We assume here, however, that by eliminating walking through the provision of transport facilities, the farmers would have enough strength left at the end of the day to put in extra 30-60 minutes to attend to the bush fallow. Indeed, this is a strong assumption and thus the estimated benefits are probably too large. However, others may interpolate to approximate other assumptions as to the effect of eliminating walking.

in major season land, 50 percent more major season land, 100 percent more cash and borrowing limit fixed at ¢20.00 per acre; 6) 200 percent more land (major season), 150 percent more cash and borrowing limit set at ¢25.00 an acre; and 7) 300 percent more land, 200 percent more cash and borrowing limit set at ¢30.00 an acre. Situations 2, 4, 5, 6, and 7 can be thought of as a sequence of resource expansion in land and capital. The analysis of Cateogry I farms was restricted to the first three situations. The idea was to concentrate more on the Category II or transitional farmers who are earlier adopters of innovation.

In Phase II, since borrowing was not constrained, only four resources situations studied 1) no change in the initial resource situation given for Phase II in Chapter V; 2) an increase of labor hiring coefficient from .66 to 1.0; 3) minimum cropping limits set for maize in both the major and minor seasons, while at the same time allowing more land renting and clearing up to specified limits;[4] 4) elimination of the minimum acreage restraints put on maize in (3) above, but retaining land renting and clearing, up to the specified limits as in situation 1, Phase II. Again, for the same

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[4] In the major season, land renting was allowed up to a limit of 20 acres. In the minor season, the limit was 10 acres. The maximum maize acreage constraint was 20 acres in the major season and 10 acres in the minor season. The minimum constraint allowed was the initial major season acreage in Phase I, and for the minor season it was also the initial minor season acreage in Phase I.

reason given above, the analysis of Category I farms was confined to the first two situations.

The underlying policy issues in this analysis were: 1) size expansion of cropped land; 2) making more money capital available through credit; and 3) making it possible for labor to work a full eight hours a day on current farm operations through measures that will reduce travel time (walking) to and from farms.

Discussion of Category II Farms by Region: Phase I Category II Farms--Central Region

Table 6.1a summarizes the programmed incomes under the seven alternative resource restraints. An examination of column 1 shows that there was no difference between situations 1 and 2. The MVP of land given in column 2, row 1, is relatively low (2.02) suggesting that land was not a very binding constraint. An increase of labor inputs increased gross return by 15 percent. The income gain for situations 4 to 7 ranged from 21 percent to 145 percent. As the resource levels varied (land and operating capital) their respective MVPs declined as expected. In Table 6.1b, the resulting resource organizations are given. Column 1a to 1g correspond to the seven resource situations. The gross returns per acre, per man hour of labor and per unit of capital were high in the initial resource situation, but gradually decreased as the farm size or resource level increased, again indicating diminishing return to land, labor and capital,

Table 6.1a. Net Income and Marginal Value Products with Resource Expansion on Transitional Farms: 24 Category II Farms, Central Region, Ghana, 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in laitial resource	2028.7		2.02	0	7.32		1.1		.3			1.2
2. additional land clearing of own or rented unused land	2028.7		2.02	0	7.32		1.1		.3			1.2
3. labor inputs through deletion of overhead labor and the conversion of labor coefficients from 0.66 to 1.0	2330.1	15	1.74		9.35		.91		.19			.97
4. 30% more major season land, 50% more cash and borrowing limit set at 20.0¢/acre	2459	21	1.38		6.68		1.02		1.1			1.1
5. 80% more land, 100% more cash and borrowing limit set at 20.0¢/acre	2997.4	47	.78		5.5		.86		.92		1.12	.92
6. 220% more land, 150% more cash and borrowing limit set at 25.0¢/acre	4375.7	45	.79		5.2		.83	.12	.89		1.1	.89
7. 300% more land, 200% more cash and borrowing limit set at 30.0¢/acre	4979.6	145	1.0		4.03	.81	.67	.95	.72		.95	.72

Source: Computed

Table 6.1b. Summary of Economic Measures of Efficiency Category II Farms, Central Region, Ghana, 1972-73.

Measure	Unit	Resource Level						
		1A	1B	1C	1D	1E	1F	1G
1. Gross Revenue	¢	2028.7	2028.7	2330.1	2459.0	2997.4	4375.7	4979.6
2. Total Acres Farr'd	Acre	4.3	4.3	4.7	5.0	6.4	9.0	10.21
3. Amt of Cash	¢	74.6	74.6	74.6	111.92	149.22	186.53	223.8
4. Amt Borrowed	¢	104.55	104.55	104.55	129.2	179	397.5	497.0
5. Total Cash Used		179.15	179.55	179.55	241.12	328.22	584.03	720.8
Hired Labor	Hrs	663	663	484	1068	1650	3391	4340
6. Total Labor Used		2958	2958	2618	3547	4367	6457	7470
Family Labor	Hrs	2295	2295	2134	2479	2717	3066	3130
A. Return per Acre	¢	471.79	471.79	495.76	491.8	468.3	486.19	487.72
B. Return per Man/Hr	Hrs	.6858	.6858	.89	.693	.69	.68	.67
C. Return per Capital	¢	11.32	11.32	12.98	10.2	9.13	7.49	6.9
D. Amt Borrowed/Acre	¢	24.3	24.3	22.24	25.84	27.97	44.17	48.68
E. Ratio of Hired Labor to Total Labor	%	22.41	22.41	18.49	30.1	37.78	52.5	58.10

Source: Computed

respectively. As the size level increased, labor hours per acre, amount of indebtedness per acre and the ratio of hired labor to the total labor inputs increased progressively.

As far as labor use was concerned, except in situation 7, labor in period 1 was not limiting. Similarly, labor available was not limiting in period 3 till situation 6 was reached, and in periods 4 and 5, labor was not limiting till situation 5 was reached. In the periods in which labor was limiting, the MVP of labor continued to be greater than the wage rate (see also Table 5.4, Chapter V). This suggests that the farmers could expect a return to their labor which was not only equal to what hired labor could earn, but actually above it. In situations 1 to 5, when more than 50 percent of the labor inputs was supplied by the family itself, there were more periods in which the MVP of labor was zero (i.e., substantially below the wage rate), indicating that the farmers would be maximizing returns per acre rather than attempting to equate MVP with wage rate or the marginal factor cost.

Category II Farms--Eastern Region

It will be seen from Table 6.2a that in situation 1 both major season land and minor season land were limiting whereas cash expense was not. As expected in situation 2, as the land constraint was relaxed, the MVP per unit of land declined, whereas that of cash expense increased (i.e., from ¢.009 to ¢7.2). With increased labor availability in

Table 6.2a. Net Income and Marginal Value Products with Resource Expansion on Transitional Farms: 22 Category II Farms, Eastern Region, Ghana, 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in resource	2662.3		744.4	62.5	.009		.13					.14
2. additional land clearing of own or rented unused land	3181.6	20	277.6		7.2		1.1					.93
3. increased labor supply through the deletion of overhead labor and the conversion of labor coefficient from .66 to 1.0	2700.2	2	760	64.5	.009		.09					.10
4. 30% more major season land, 50% more cahs and borrowing limit set at 20.0¢/acre	3332.6	25	616	15	.96		.26				.37	.28
5. 80% more land, 100% more cash and borrowing limit set at 20.0¢/acre	4384.7	65	575		1.42		.32				.46	.34
6. 220% more land, 150% more cash and borrowing limit set at 25.0¢/acre	6037.1	27	0	0	5.4		.84	1.2	.9		1.2	.91
7. 300% more land, 200% more cash and borrowing limit set at 25.0¢/acre	6640.6	149	0	0	5.4		.84	1.2	.9		1.2	.91

Source: Computed.

situation 3, the land became very limiting whereas cash expense was hardly a limiting factor. Examination of Table 6.2b shows that in that situation only 170 units of labor were hired, a figure representing 5.72 percent of the overall labor inputs. The income gain in situation 3 over situation 1 was 2 percent, hardly of significance. The only noticeable change in the two situations was the increase in labor use efficiency, i.e., 571 hours per acre of labor were used in situation 3 as compared with 994 hours in situation 1.

As both land and cash expense resources expanded from situation 4 onward, the MVP of land declined and became zero in situations 6 and 7. However, the MVP of cash expense increased pari passu. The erratic behavior of the MVPs of land and cash expense seems to suggest that an alternative resource expansion procedure would be preferable, particularly one that expanded the most limiting source (land) and kept cash expense, which was already adequate in the initial situation constant.

In all the situations, more than 60 percent of labor requirements were supplied from family sources, though the percentage of hired labor to total labor inputs increased as the resource was expanded. The greatest income gain was in situation 7 (149 percent). However, the most feasible resource expansion would seem to lie between situations 5 and 6. If money is made more available, for instance, through credit, then according to neo-classical theory of the firm,

Table 6.2b. Summary of Measures of Economic Efficiency Under Varying Levels of Prices, Category II Farms, Eastern Region, Ghana, 1972-73.

Measure	Unit	Resource Level						
		1A	1B	1C	1D	1E	1F	1G
Gross Income	¢	2662.3	3181.6	2700.2	3332.6	4384.7	6037.1	6640.6
Total Acres Farmed	Acre	5.2	6.22	5.2	6.2	8.11	11.2	13.2
Total Cash Used	¢	203.42	210.82	165.02	271.33	365.2	564.75	682
Amt Borrowed	¢	78.4	85.8	40.5	83.8	115.2	257.2	322
Amt Cash Used	¢	125.02	125.02	125.02	187.53	250.0	312.55	360.0
Hired Labor Used	Hrs	343	594	170	600	1010	1949	2455
Family Labor Used	Hrs	3460	3394	2800	3637	3832	4205	4320
Total Labor Input	Hrs	5167	3988	2970	4237	4842	6154	6775
1. Return /Acre	¢	511.98	511.52	219.2	537.52	540.34	539.03	503.08
2. Return/Man Hour	¢	.52	.80	.91	.79	.91	.98	.98
3. Return/Capital	¢	13.08	15.09	16.36	12.28	12.0	10.6	9.74
4. Amt Borrowed/Acre	¢	15.0	13.79	7.79	13.52	14.20	22.96	24.39
5. Labor Hrs/Acre	Hrs	994	641	571	683	597	549	513
6. Ratio of Hired Labor to Total Labor	%	6.6	14.89	5.72	14.16	20.86	31.67	36.24

Source: Computed.

it is better, from a profit maximizing point of view, to borrow money up to the point where the MVP of additional unit of it equals interest plus the principal to be paid. This condition may be satisfied with a resource expansion in between situation 5 and 6.

Category II Farms--Ashanti Region

Table 6.3a and Table 6.3b give the details of the results of the seven alternative resource situations in Ashanti region. It can be seen from Table 6.3a that because land was already adequate in the initial situation, its expansion alongside with capital, left its MVP unchanged at zero. A more feasible expansion policy was to expand cash expense. As expected, the MVP of cash expense decreased successively with the expansion of this resource. In Phase II, when an optimum amount of borrowing took place (¢1219.43), the MVP per unit of land in this representative farm rose to ¢446.76 with the MVP per unit of money capital--¢.06--just equal to the interest rate.

The income gain from resource expansion in situation 3 was 11 percent while that of situation 7 was 185 percent. The maximum optimum income in Phase II for this category of farms was ¢5900. It appears, therefore, that if the level of operating capital used in situation 7--¢975 had been used in situation 2 (i.e., to make it somewhat comparable to Phase II situation), the resulting optimum income would have approximated the level indicated in situation 7.

Table 6.3a. Net Income and Marginal Value Products with Resource Expansion on Transitional Farms: 22 Category II Farms, Ashanti Region, Ghana 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in initial resource	2068.3		0	0	7.8		1.2	.06			.06	
2. additional land clearing of own or rented unused land	2068.3	0	0	0	7.8		1.2	.06			.06	
3. increased labor supply through the deletion of overhead labor and the conversion of labor coefficient from .66 to 1.0	2298.9	11	0	0	9.4		.93	.06			.06	
4. 30% more major season land, 50% more cash and borrowing limit set at 20.0¢/acre	2659.9	29	0	0	6.8		1.06	.06			.06	.53
5. 80% more land, 100% more cash and borrowing limit set at 20.0¢/acre	3305.1	60	0	0	5.8		.93	.67	.06		.06	
6. 220% more land, 150% more cash and borrowing limit set at 25.0¢/acre	4820.9	133	0	0	3.73	.81	.64	.76	.67		.67	
7. 300% more land, 200% more cash and borrowing limit set at 25.0¢/acre	5892.9	185	0	0	3.73	.81	.64	.76	.67		.67	

Source: Computed.

Table 6.3b. Summary of Measure of Economic Efficiency Category II Farms Ashanti Region, Ghana, 1972-73.

Measure	Unit	Resource Level						
		1A	1B	1C	1D	1E	1F	1G
Gross Income	¢	2068.3	2068.3	2298.9	2659.9	3305.1	4820.9	5892.9
Total Acres Farr'd	Acre	3.8	3.8	4.2	5.2	7.4	13.5	16.8
Total Cash Used	¢	210	210	210	291.7	397.2	713	1005
Amt Cash Used	¢	87	87	87	130.5	174	217	261
Amt Cash Borrowed	¢	123	123	123	161.2	223.2	496	744
Amt Hired Labor	Hrs	727	727	566	1130	1637	3388	5375
Amt Family Labor	Hrs	3492	3534	3578	3701	3798	3624	3624
Total Labor Input	Hrs	4219	4261	3593	4831	5435	7012	8999
1. Return/Acre	¢	544.28	544.28	547.36	511.5	446.6	357.1	350.77
2. Return/Man Hrs	¢	.49	.49	.64	.55	.61	.69	.65
3. Return/Capital	¢	9.85	9.85	10.95	9.12	8.32	6.76	5.86
4. Amt Borrowed/Acre	¢	32.36	32.36	29.28	31.0	30.16	36.74	44.29
5. Labor Hrs/Acre	Hrs	1110	1121	855	929	734	519	536
6. Ration of Hired Labor to Total Labor	%	17	17	15.75	23.39	39.11	48.31	59.73

Source: Computed.

It will be seen in Table 6.3b that as the resource levels expanded, the ratio of hired labor to total labor input increased. The amount of borrowed money used per acre also increased from situatons 4 to 7.[5] The return per unit of capital again declined in that range, but in general, the returns per acre and per man hour of labor displayed an erratic behavior.

Category II Farms--Brong-Ahafo Region

In Table 6.4a, it will be seen that in situaton 3, there was an income gain of 7.4 percent. As expected, the MVP per unit of labor by period declined as compared with the initial situation. However, the MVPs per unit of money capital and per unit of land increased, also as expected. From situations 4 to 7, the ratios of MVP per unit of labor by period remained constant and above the wage rate, except in periods 7 in situations 6 and 7 when the MVP just equated its salvage value. The values of the MVP would indicate that the farmers throughout the resource expansion sequence could increase their earnings if they were prepared to put in extra hours of work. In Table 6.4b, the labor use per acre was the lowest in situation 3, indicating labor use efficiency in relation to other situations.

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[5]Situations 4 to 7 more clearly depict size sequence expansion of resources of land and capital.

Table 6.4a. Gross Income and Marginal Value Products with Resource Expansion on Transitional Farms: 22 Category II Farms, Brong-Ahafo Region, Ghana 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in initial resource	5,070.3		201.4		1.81	.13	.114	.114	.123	.123	.102	.102
2. additional land clearing of own or rented unused land	5,392.6	6.4	129.5		4.4	.03	.01	.01	.02	.02		
3. increased labor inputs through the deletion of overhead labor and conversion of labor coeffieicnt for .66 to 1.0	5,444.0	7.4	228.8	1.43	1.85	.02	.008	.008	.014	.014		
4. 30% more major season land, 50% more cash and borrowing limit set at 20.0¢/acre	6,513.0	28.5	201.4		1.81	.133	.114	.114	.123	.123	.102	.102
5. 80% more land, 100% more cash and borrowing limit set at 20.0¢/acre	7,556.3	49.0	201.4		1.81	.133	.114	.114	.123	.123	.102	.102
6. 220% more land, 150% more cash and borrowing limit set at 25.0¢/acre	10,101.0	99.2	216.6		1.46	.133	.114	.114	.123	.123	.102	.102
7. 300% more land, 200% more cash and borrowing limit set at 30.0¢/acre	12,459.0	145.7	216.6		1.46	.133	.114	.114	.123	.123	.102	.06

Source: Computed.

Table 6.4b. Summary of Measures of Economic Efficiency Category II Farms, Brong-Ahafo Region, Ghana, 1972-73.

Measure	Unit	Resource Level						
		1A	1B	1C	1D	1E	1F	1G
Gross Income	¢	5070.3	5392.6	5444	6513	7556.3	10101	12459
Amt Borrowed	¢	346.65	346.65	346.65	449	519	865	1081.25
Amt Cash Used	¢	250	250	250	375	500	625	750
Total Acres Used	Acre	17.4	19.74	23.07	22.47	25.95	37.18	55.62
Total Cash Borrowed	¢	596.65	596.65	596.65	824	1019	1490	1831.25
Amt Hired Labor	Hrs	11252	13842	7778	17043	20962	32064	41102
Amt Family Labor	Hrs	6370	6370	6370	6370	6370	6370	6370
Total Labor Inputs	Hrs	17622	20212	14148	23413	27332	38434	47472
1. Return/Acre	¢	291.4	273.18	236.28	289.85	291.19	271.68	224.0
2. Return/Man Hr	¢	.29	.27	.38	.28	.28	.26	.26
3. Return/Capital	¢	8.5	9.04	9.12	7.9	7.42	6.8	6.8
4. Amt Borrowed/Acre	¢	19.2	17.56	15.02	19.98	20.0	23.27	19.44
5. Labor Hrs/Acre	Hrs	1013	1024	612	1042	1053	1034	854
6. Ration of Hired Labor to Total Labor	%	63.8	68.5	54.98	72.79	76.69	83.43	86.58

Source: Computed.

In all the situations, except situation 3, the ratio of hired labor to total labor inputs was above 60 percent. At the same time, family labor in situation 4 to 7 was used to the limit in all periods. The return per unit of capital and labor declined from situation 2 (ignoring situation 3) over the sequence of land and money capital resource expansion. The highest gain in income seems to be in situation 7, but even there the magnitudes of the various MVP per unit of resource indicate that further resource expansion will be profitable.

Discussion of Category I Farms--Phase I

Category I farms constituted 70 percent of the farms in the sample area, a figure that reflects the pattern existing in the country, but they did not receive as detailed an examination as the Category II farms. Because these farmers are less innovative, a narrower list of policy options was used to identify the effects on the group. Table 6.5 to Table 6.9, will be involved in the discussion.

It is apparent from Table 6.5 that much income gain for the Category I farms would be obtained by expanding the use of the most limiting resources--land and money capital. In evaluating the gains from optimization, using the economic measures of efficiency as shown in Table 6.6, it is evident that, given the present state of arts and the fact that the farmers had access to fertile land--a situation which as mentioned earlier, justified mixed-cropping--the rate of

Table 6.5. Net Income and Marginal Value Products with Resource Expansion on Traditional Farms 50 Category I Farms, Central Region, Ghana, 1972-73.

Situation	Programmed Income	Given over initial Situation	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in resource	1824.4		520	0	.09	.13						
2. additional land clearing of own unused land	2769.48	52	329	0	4.2	.68						
3. deletion of overhead labor and conversion of labor coefficient for 0.66 to 1.0	1845.87	1.1	530	0	0	.09						

Source: Compiled from Survey Data

Table 6.6. Net Income and Marginal Value Products with Resource Expansion on Traditional Farms 72 Category I Farms, Volta Region, Ghana, 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor By Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in resource	1104.3		565.4	49.2	.06	.13		.06				
2. additional land clearing of own or rented unused land	1232.5	12	278.8	1.25	8.5	1.15		.06				
3. deletion of labor and conversion of labor coefficient from 0.66 to 1.0 with additional land clearing	1326.7	20	315.4		9.4	.86		.06				

Source: Compiled from Survey Data

Table 6.7. Net Income and Marginal Value Products with Resource Expansion on Traditional Farms: 50 Category I Farms, Eastern Region, Ghana, 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in resource	1867.3		604.6	52	.009		.13					
2. additional land clearing of own or rented land	2793.3	5.0	319.95		8.46		.07	.07	1.0			.5
3. increased labor supply through the deletion of overhead labor and the conversion of labor coefficient from .66 to 1.0	1881.7	.08	612.7	52	.14		.09					.09

Source: Computed.

Table 6.8. Net Income and Marginal Value Products with Resource Expansion on Traditional Farms: Category I Farms, Ashanti Region, Ghana, 1972-73. [52]

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in initial resource	1304.3		256	0	.73	.06	.25	.06	.06	0	.25	.06
2. additional land clearing of own or rented unused land	1340.7	2.7	1102	0	3.63	.06	.65	.06	.06	0	.06	.06
3. increased labor supply through the deletion of overhead labor and the conversion of labor coefficient from .66 to 1.0	1376.6	5.5	312	11.0	.31	.06	.122	.06	0	0	.12	.06

Source: Computed.

Table 6.9. Gross Income and Marginal Products with Resource Expansion on Traditional Farms: 52 Category Farms, Brong-Ahafo Region, Ghana 1972-73.

Situation	Programmed Income	Gain	Land major	Land minor	Cash	Labor by Periods 1	2	3	4	5	6	7
	Cedis	Percent	Marginal Value Products in Cedis									
1. no change in initial resource	1798.3		(slack)	(slack)	10.4	.345	.06	.59				.06
2. additional land clearing of own or rented unused land	1798.3		(slack)	(slack)	10.4	.345	.06	.59				.06
3. increased labor inputs through the deletion of overhead labor and conversion of labor coefficient from .66 to 1.0	1872.5		(slack)	(slack)	10.6	.344	.06	.58				

Source: Computed.

return by all comparative measures were substantial. Most of the gains were attributable to area expansion.

With the exception of Category I farms in Brong-Ahafo land proved to be the most limiting constraint for indigenous farms in the initial situation. In Ashanti, with the relaxation of the land constraint in situation 2, the MVP per acre of land declined while that per unit of capital increased from ¢.73 to 3.63 (Table 6.8). The income gain was 2.8 percent. In situation 3, the gain in income was 6 percent. Comparing situations 1 and 3, with respect to labor use by period, it is evident that only in period 2 was the MVP per unit of labor greater than the wage rate. In other periods, the MVP was much below the wage rate and the bulk of farm labor was supplied by the family itself. In situation 3, the ratio of hired labor to total labor input was 10.86 percent (Table 6.10). On examination of Tables 6.5 to 6.9, the situation described with respect to Ashanti region appears to be the general pattern: More dependence on family for labor supply, indicating here again that the farmers would be better off by maximizing returns per acre rather than attempt to equate MVP with wage rate.

The income gains through addition of land clearing ranged from 52 percent in Central region to zero in Brong-Ahafo. In Brong-Ahafo, money capital rather than land was the more limiting resource.

The average returns per acre, per unit of capital and per unit of labor were high and compare favorably with

Table 6.10. Summary of Economic Measures of Efficiency Under Varying Resource Level Category I Farms, All Regions.

Item	Unit	Central Region			Volta Region			Eastern Region			Ashanti Region			Brong-Ahafo Region		
		1a	1b	1c	1a	1b	1c	1a	1b	1c	1a	1b	1c	1a	1b	1c
Gross revenue	¢	1824.4	2769.5	1845.9	1104.3	1232.5	1326.7	1867.3	2793.3	1881.7	1304.3	1340.7	1376.6	1798.3	1798.3	1872.5
Total acres	¢	3.6	6.6	3.6	3.8	4.3	4.3	5.0	5.0	3.9	5.8	6.3	6.3	6.1		
Amount of cash	¢	103.7	103.7	94.6	27.0	27.0	27.0	69.7	69.7	69.7	86.3	86.3	86.3	125.2	125.2	125.2
Amount borrowed	¢	12.3	91.2		53.9	95.0	36.5	53.9	59.0	36.5	107.8	107.8	107.8			
Total cash used	¢	116.0	194.9	94.6	80.9	122.0	63.5	123.6	123.6	106.2	194.1	194.1	194.1	125.2	125.2	125.2
Hired labor	Hr	558	121	314	91	156	117	365		191	751	728	437			
Family labor	Hr	3540	4033	2992	2755	2852	2400	3316	3054	2879	3610	3569	3586	5037	5037	4652
Total labor inputs	Hr	4098	4154	3018	2846	3008	2451	3681	3054	3070	4361	4297	4023	5037	5037	4652
1 return per	¢	506.8	496.4	512.7	294.4	287.3	308.5	377.2	423.2	380.1	263.5	341-2	239.0	285.4	285.4	307.0
2 return per hr	¢	.4	.7	.6	.4	.4	.5	.5	.9	.6	.3	.3	.3	.4	.4	.4
3 return per capital	¢	15.7	14.2	19.5	13.6	13.0	20.9	15.1	22.6	17.7	6.7	6.9	7.1	14.4	14.4	15.0
4 amount borrowed per acre	¢	3.4	13.8		14.4	22.1	8.5	10.9	8.9	7.4	21.8	27.4	18.7	0	0	0
5 labor hours per acre	Hr	1138	629	838	758	701	570	744	463	620	881	1093	698	800	800	763
6 ratio hired labor to total labor	%	5.8	2.9	10.4	3.2	5.2	9.8	9.9	0	6.2	17.2	16.9	10.9	0	0	0
Cropping Plan																
1 maize (minor)	Acre				1.8	1.8	1.8	2.0	1.0	2.0	1.2		2.0			
2 MCO	Acre		5.6						4.9					1.5	1.5	.10
3 MCOY	Acre								.5		3.8	3.9	3.7			
4 MPOV	Acre													4.6	4.6	5.3
5 MCPOY	Acre							3.0	3.0							
6 MCPOYV	Acre	3.6	1.0	3.6												
7 MCOYV	Acre				2.0	2.2	2.6									
8 MPOYV	Acre												.1			

Source: Computed.

corresponding figures in Category II farms Phase I (Table 6.10). In situation 3 in all the regions, labor use efficiency in relation to other situations is indicated by the magnitudes of labor hours used per acre.

A picture that emerges is that by making more credit available to the farmers, by removing the constraint that brings about underutilization of farm labor (situation 3) and by making it possible to supply farm inputs such as planting materials and simple farm implements to the farmers in sufficient numbers, there will be some income gains, as indicated in Table 6.5 to 6.9. The latter policy option would be supported by the magnitudes of the MVPs per unit of inputs shown in Table 5.4a, Chapter V.

Programmed Income Category II Farms--Phase II

The discussion in this section is related to Appendix Tables B.1a to Table B.4b. The alternative resource situations to be considered here are: 1) initial resource with unlimited amount of borrowing, column 2A; increased labor use through the conversion of the labor hiring coefficient from .66 to 1.0, column 2B; allowing land clearing up to a limit of 40 acres (20 acres in the major season and 20 acres in the minor season) while at the same time putting maximum and minimum acreage constraint on pure-stand maize, but maintaining land renting activities in both the major season (RENTM) and minor season (RENTN) with their corresponding constraints (RENTLIMT and RENTLINT), column 2D.

In the programming results presented in Chapter V, it was observed that major season maize in pure-stand was in a very weak competitive position as compared with the crop mixtures. A justification for imposing maize maximum and minimum constraints was to find out the effect on income and farm organization if pure-stand maize cropping was forced into the optimum cropping plan in order to meet some of the requirements of the Maize Crop Improvement Project.

Central Region

One effect of converting the labor hiring coefficient from the previous level (.66 to (1.0) was to ensure that by eliminating the average of an hour a day spent on walking, hired labor could be made to contribute at least eight hours of service for the same pay. Column 2A in Table B.4a presents the programming results. The gross income was ¢4835.94, representing a gain of 3.4 percent over the initial situation (Column 2A). The average return per acre increased slightly, but a sharp reduction in labor inputs per acre was achieved.[6] The programmed returns per unit of capital and labor were ¢9.13 and ¢1.06, respectively--a marked improvement over the corresponding figures in the initial situation. The ratio of hired labor to total labor inputs was 28.95 percent as against 52.64 percent indicating a fall in employment, but

[6]By increasing the number of hours worked per day from 5.66 hours to 8 hours, say 1 cedi spent on hired labor will get more work done than before.

high income gain. The programmed cropping plan that emerged was unchanged.

The programmed income that emerged was ¢4647.28, a slight decrease from the income in the initial period. The programmed cropping plan showed some specialization with 21.43 acres devoted to major season maize in pure-stand, 14.0 acres to minor season maize in pure-stand and 7.05 acres to maize-cassava-yam mixtures. The gross income per acre, however, decreased to ¢109.40 from the previous level of ¢374.64. By removing the maize acreage constraint (situation 2D), the gross income jumped to ¢14,380.65, leading to greater return per unit of capital, per unit of labor and per acre.

Eastern Region

In situation 2B, it is evident from Appendix Table B.3a that there was an income gain of ¢63.63, as compared with situation 2A. The returns per acre, per unit of capital and per hour of labor increased slightly. As expected, labor hours used per acre declined from 689 to 618.

With the imposition of maize acreage limits, the gross income declined from ¢4051.77 to ¢3855.21. The average returns per acre of land, per unit of money capital and per unit of labor declined rather drastically to ¢133.02, ¢2.22 and ¢0.34, respectively. With the removal of the maize acreage limits in situation 2D, the gross income

increased to ¢13,476.66 with the other related average measures correspondingly increasing also.[7]

Ashanti Region

By increasing the coefficient on labor hours worked per day (situation 2B), the gross income increased to ¢6228.87, representing an increase of ¢328.03 or 5.6 percent over the gross income in situation 1. The labor hours used per acre declined as was expected, but the average returns per unit of capital, per unit of labor and per acre increased (Table B.2a).

With the imposition of the maize acreage limits in situation 2C, the gross income was ¢4088.12 as compared with a gross income of ¢14,225.41 when the constraints were removed in situation 2D. The average return per acre in situation 2C was ¢119.54 as against ¢415.95 in situation 2D.

Brong-Ahafo Region

It can be seen in Appendix Table B.1a that by increasing coefficient on labor hours worked per day, there was an increase in income of ¢386.83 or a gain of 4.2 percent over the income in situation 2A. Again, as expected, there was a reduction in labor hours used per acre, i.e., 545 hours of labor were used in situation 2A as against 722 hours in situation 2A.

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[7]It did not return to the previous level (situation 2A) because the land renting activity was retained, so that the overall acreage expansion was 29.244 acres as compared with 9.224 acres in situation 2A.

With the imposition of maize acreage limits, 22.8 acres were allocated to maize in the major season, 19.77 acres to maize in the minor season (Appendix Table B.1b), and 18.54 acres to maize-cocoyam-yam-pepper enterprise. With the removal of the constraints, pure-stand maize in the major season did not come into the optimum solution. It is shown in the Appendix Table B.1b to be ¢371.79, too expensive to be forced into the plan. The resulting gross income in situation 2C was ¢8,285.42, as against ¢16,762.27 in situation 2D, a difference of ¢8,476.85.

Discussion of Category I Farms--Phase II

For Category I farms in Phase II, two resource situations were examined: 1) the initial situation (2A) and increasing coefficient on labor hours worked per day (situation 2B). The results are summarized in Appendix Table D.2. The gain in income ranged from 3 percent in Brong-Ahafo region to 10.9 percent in Volta region as a resulting of shifting from situation 2A to situation 2B. With the exception of the Volta region, the optimum cropping organization remained the same in both situations. The overall picture that emerges is not only income gain in situation 2B over situation 2A, but 1) returns per unit of labor, per unit of capital and per acre increased; 2) there was a reduction in labor used per acre in situation 2B as compared with situation 2A and 3) with the exception of Category I farm in Ashanti region, the amount of money

borrowed per acre declined in situation 2B as compared with situation 2A.

With increased availability of labor and with borrowing allowed to its optimum point where the MVP of additional unit of capital was equal to its marginal factor cost, land became the more limiting factor. Thus, for all the representative farms in the regions, the marginal value product per unit of land increased in situation 2B as compared with situation 2A.

Concluding Remarks

The preceding discussion in this chapter, aimed at three broad policy issues: 1) making more cash available through credit expansion; 2) increasing size of farms; and 3) eliminating walking time for labor. In connection with the Phase I static linear programming model, seven alternative resource situations were examined to throw some light on the most feasible path of resource expansion for Category II farms. Three alternative situations were examined for Category I farms. In connection with the Phase II poly-period model, four alternative situations were examined for Category II farms and two situations for Category I farms.

According to neo-classical production economics, maximum output from agriculture is forthcoming from given resources only as mobile resources such as money capital and labor are applied to immobile resources, such as land in a manner that the ratio, $\frac{MVP}{MFC}$, is approximately equal in

all its uses. The principle of factor proportionality also suggests a liberal application of the resource in plentiful supply, in order to economize on the relatively scarce resource. Empirical studies, such as this one, which attempt to operationalize these economic principles, are of value in suggesting the path of economic adjustments and policies designed to promote not only increased agricultural production, but also efficient agricultural production. However, the earlier caveat regarding extrapolating the MVP beyond one unit should be remembered when policy actions are contemplated.

The inter-area and inter-situation comparison of marginal productivity in the Phase I model in this chapter has provided some insight into the policy issues posed. Relatively high marginal value product per unit of land in Eastern, Volta and Brong-Ahafo (for Category II farms) indicates that farm expansion in these regions should receive special attention. In Central and Ashanti regions, the emphasis would be on capital.

Situation 2A in Phase II model clearly demonstrates the weak competitive position of maize. In order to force major season pure-stand maize into the crop plans, it became necessary to impose minimum acreages. The analysis indicates that this is an expensive thing to do. Again, the analysis also shows that permiting labor to work a full eight hours a day will prove profitable for the farmer. What this study

did not investigate is the cost of making such a situation possible.

In the next chapter, these policy issues will be explored further. Some alternatives not empirically tested in this study will also be discussed.

CHAPTER VII

POLICY ISSUES, SUMMARY AND CONCLUSIONS

The study has employed static linear programming and poly-period programming to investigate the most profitable farm organizations for representative farms identified in the study areas in Ghana. It is the purpose of this chapter to relate the programmed results to the micro-economic aspects of decisions with regard to policies or programs affecting 1) changes in the provision of credit; 2) changes in infrastructure such as the provision of a network of feeder roads and public transit services to reduce the time farmers spent walking to farms; 3) on-farm storage organization as a contributing factor in the profit maximizing efforts of the farmers; 4) changes in the subsidized prices of inputs such as fertilizers and other chemicals; 5) changes in guaranteed minimum price for maize; and 6) acreage expansion or the size factor of smallholder subsistence production. The first five programs are specific development programs subsumed under the Maize Crop Improvement project for the agricultural areas included in this study. The strategy used in this section of the chapter is to focus on policy-related empirical findings in the study. Other issues which

were not empirically tested in our study will be introduced inasmuch as they have a bearing on the relevant policy issue being discussed.

Credit

It is the policy of the Ghanaian government to provide cheap credit to "small" farmers as well as "big" farmers. The central issue revolves around this question: How can credit be made an effective instrument in developing agriculture in Ghana? This question has wide ramifications encompassing both micro and macro aspects of decision-making. We shall mainly address ourselves to the former in our discussion. Four sub-issues immediately are inferrable from the main question posed. They are distribution, interest rate, loan conditions and firm-household interdependence.

Distribution

On the average, 90 percent of the Category I farmers interviewed in the survey reported that they faced the problem of inadequate credit from institutional sources. The corresponding figure for Category II farmers was slightly lower--73 percent--but it is still substantial. Given the size of holding (a range of 2.41 to 17.34 acres for Category II farms and 2.0 to 6.68 acres for Category I farms--Table 3.3) and the interdependence of production, consumption and savings or investment, the traditional-cum-"transitional" farming methods have kept production per farm household at

a level which barely meets consumption requirements with little left over for savings.[1] The implication is that capital needed to purchase additional inputs or hire labor to clear more land must be borrowed. The timing of borrowings and the amounts that can be borrowed are two major considerations.[2] In the absence of making institutional sources of loanable funds easily available (in the sense that the farmers do have knowledge about where to go for credit, how far they have to travel to get the loans and whether the attitudes of the bank officials do not frustrate the efforts of the farmers to obtain loans),[3] farmers needing loans inevitably resort to traditional money lenders, who charge high interest rates.

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[1]This situation was not tested empirically in the study. It is merely a description of the situation as observed, based mainly on the smallness of the operating capital the sample farmers had to cope with.

[2]The situation is different in the United States, for instance. The farmers generally are in a position to determine how much money capital they need, whether to borrow or not and how much to borrow. Heady and Swanson, for instance, report in their study that 61.5 percent of the farmers refused to use additional credit because of risk factors. [Heady and Swanson, 1952].

[3]During the survey, questions were put to the farmers to determine the main impediments preventing them from getting credit. In addition to collateral requirements, which proved to be the major hindrance, 90 percent of the farmers reported that they had no knowledge as to where to go for credit; 85 percent reported that the bank offices were too far away from them; and 62 percent reported that they were often frustrated in their efforts by bureaucratic delays suggestive of indirect kick-back demands by the officials.

With the restrictions on borrowings removed in the Phase II, the model determined not only the optimum amount to be borrowed, but also the timing of borrowings in response to production and consumption requirements. As an illustration, the amount borrowed for Category II farms in Brong-Ahafo was ¢346.0 in Phase I. The total acreage cultivated was 17.4 acres and the gross income was ¢5,070.00. With the removal of the borrowing constraint in Phase II, the aggregate amount borrowed was ¢1,580.89 and the gross income increased to ¢9,310.01.

According to neo-classical theory of the firm, farmers wanting to maximize profit should borrow money up to the point where the marginal value product per unit of additional money invested in the farm business equals the interest rate. Table 5.8, Chapter V, gives the details of the marginal value productivity of capital used for cash expenses for representative farms in Phase II. In comparison with the return per unit of capital given for Phase I model shown in Tables 5.4a and 5.4b, it is evident that in Phase II the marginal condition for allocative efficiency postulated above is satisfied.

Under existing credit arrangements, it is evident from Table 5.4a that with respect to Category II farms, farmers in Ashanti, Brong-Ahafo and Central region suffer more from inadequacy of capital than farmers in Eastern region. For Category I farms, farmers in all the regions except Brong-Ahafo suffer from capital inadequacy (Table 5.4b).

Rate of Interest

While formulating a credit policy, inter-region and inter-category difference should be taken into consideration. A general approach for determining the credit needs of the farmers is to use the technique of resource-variable programming. This procedure will help determine the maximum amount of money that can be borrowed to maximize income. But, the cost-range reports provided along side the linear programming solutions showed that the optimum solutions were highly insensitive to charges in interest rates. For all the categories of farms and in all regions, four levels of interest rates were tried to determine their effect on income and farm organization: 6 percent, 9 percent, 12 percent and 15 percent per annum. No basic change ensued, thus substantiating the observation that the optimum solutions were insensitive to changes in interest rates. The Phase II model which eliminated the borrowing constraint emerged as a better guide to determining the optimum amount of capital needed to maximize income on individual representative farms. Presently, the credit needs of the farmers are determined by the official credit institutions, which are required by law not to charge more than 6 percent interest on the loans to the small farmers. At the same time, it must pay 7½ percent on savings deposits it receives. Thus, the cost of securing funds and making a loan to the small farmer is higher than the expected return at current interest rates.

The question then is--what interest rate to charge. Any rate of interest used in the Phase II model (i.e., whether 9 percent, 12 percent or 15 percent) would have left the basis unchanged.[4] An important guide is to have estimate of the MVP per unit of capital as reflected in the Phase model. The returns differ between regions and between categories. This would suggest a multi-interest rate structure which would be difficult to implement. A useful guide may be to strike a compromise between the rate of interest of 14 percent which the commerical banks charge and the 7½ percent which the official lending institution must pay on savings deposits it receives. The evidence is that it is the adequacy of the credit not the rate of interest which is of concern to the farmers. Farmers in the sample who received loans from money lenders paid between 100 to 200 percent interest. They probably did this because the MVP per unit of capital was very high for some farmers in some regions as implied by the Phase I results.

It is the conclusion of this study that the adequacy of credit is what claims immediate attention. The question of determination of the appropriate rate of interest must be further investigated in another study.

Conditions for Credit

Three major requirements are embodied in the granting of loans to farmers in the study areas: collateral, pure-stand cropping and a maximum of ¢15.0 an acre loan for each

farmer. Since the farmers interviewed have little or no fixed investments to act as collateral, a credit policy devised on the basis of farm planning will be more effective than one based on security of loans. The average returns per acre, per unit of capital and per man-hour of labor are substantial (Tables 5.1, 5.2, B.1a to B.4a) and would be helpful in guidng the loan-granting policies. For Category II farms, for instance the amount borrowed per acre in the model solution ranged from a low of ¢40.88 in the Eastern region to a high of ¢85.0 in Ashanti region. These are a marked departure from the bank's limit of ¢15.00 per acre. Similarly, the study has concluded that mixed-cropping is in a stronger competitive position than pure-stand cropping. The implication is that, a lending policy based on overall productivity rather than pure-stand requirement will contribute more to farm expansion and higher income gains.

Farm-Household Interdependence

The Phase II model confirms that household consumption requirements feature in the profit maximizing decisions of the representative farms. What this implies is that in addition to estimating credit needs based on production requirements, estimate should be made of family expenditure on the basis of family budget approach. The banks can separate the two types of credit needs by giving credit for productive purposes in kind in the form of implements, fertilizers, needs, etc.

Other Relevant Issues

There are other relevant issues connected with credit which are not covered in this study. Some of these are: the impact of credit on employment and income distribution; the encouragement of thrift as a condition of receiving loans and the establishment of rural credit institutions. These issues are important and merit consideration in another study.

Labor Utilization

The survey results show that the farmer walks an average of three miles to and from the farm. By Ghanaian standards, walking on bush paths with several obstacles in the form of fallen trees and rivers without bridges, this would take about 60 minutes per day. After adjusting for travel time and labor works only about two-thirds (66 percent) of the normal average of eight hours a day.[4]

In Chapter VI, the effect of removing this bottleneck on farm income and farm organization was determined by eliminating; 1) labor overhead on the part of the family labor, and 2) changing labor hiring coefficient from .66 to 1.0. The effects of these changes on income, labor utilization, amount of money borrowed and farm organizations are summarized in Tables 5.6 and 5.7 for the Phase II model and Tables 6.1 to 6.6 for the Phase I model.

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[4] The implication is that 1 unit of hired labor supplies .66 hours of labor per day. The coefficients of labor hiring activities by period given in Table 4.3 reflect this observation.

Using Category II farms, Brong-Ahafo region as an illustration, there was an income gain of 7.4 percent with 1.43 acres of minor season land which was in slack in the initial phase being brought into cultivation. The amount of labor hired per acre was reduced from 1,013 hours in the initial situation to 612 hours suggesting labor use efficiency. The returns per unit of capital increased from ¢8.5 to ¢9.12; that per man hour of labor from ¢0.29 to ¢0.38 and gross return from ¢5,070.3 to ¢5,444.0.

As the figures in the tables indicate, there are minor inter-region and inter-category variations. But, the general tendency was an overall improvement: greater income and less labor used per acre.

The implication is that any measure than can help remove the bottleneck that leads to this type of labor utilization will prove profitable to the farm business. A possible solution, as both private and public measure, is a network of feeder roads to open up the geographic areas. Farmers, for instance, can be bussed to their farms.

The results of this aspect of the study has implications for other issues not empirically verified in this study. For instance, 1) the benefit-cost ratio of constructing feeder roads needs investigation, 2) market-related benefits and cost, i.e., location of storage facilities at points near consuming centers; prompt evacuation of perishables as soon as they are harvested, etc.; 3) the possibility of feeder road construction paving the way for settled farming so that

the farmers need not walk long distances to their farms; and 4) associated with the last issue is the feasibility or infeasibility of establishing neighborhood schools up to secondary school level, so that school children could stay longer periods with their parents and help in the farm work. All these issues warrant consideration.

Storage

A storage sub-model was incorporated into the Phases II and III of the poly-period model in order to provide some guidelines to farmers as to the most feasible timing of the sale of commodities such as maize, yams and pepper. In arriving at the programmed solution, marginal value products associated with the output transfer or inventory carry-over from period to period were computed. These are shown in Appendix E. The MVPs indicate the shadow prices associated with the balance equations and also indicate the rate of change in the objective value or the optimum income if slightly more or slightly less of that particular commodity were made available. According to Driebeck,

> ". . .if these shadow prices had been used in the objective function, each stage of the storage process would have been optimized by itself and a solution identical to the overall solution would have been arrived at." [Driebeck, 1969, p. 96]

The market prices of the commodities in the various periods are given in row II of Appendix E in each region.

The results show what income gain per unit of commodity would have been if the farmers had the know-how and resources to organize year-round storage operations. Thus, the potential income gains from storage suggest a close look at the benefit-cost ratios of encouraging on-farm storage. Three policy options that warrant considerations are:

1. Provision of the requisites including credit to the farmers to build the storage facilities themselves.
2. Encouragement of cooperatives to establish the storage facilities.
3. Public provision of these facilities to be operated on the behalf of the farmers at a cost.

Plantains and cassava in their natural form cannot be stored for a long-period. However, when processed into chips or flour, these can be stored for a considerable length of time. Thus, an important linkage of agricultural output increasing efforts with rural industries may make substantial contribution toward improving rural welfare.

Effects of Varying Maize Price on Farm Income and Adjustment

The linear programming solution involved in this study used the actual selling and buying prices of maize to reflect regional differences. Because the government's guaranteed minimum price for maize was fixed at a level common to all the farming areas, four levels of the same price for all

regions were examined for their effect on the profit maximizing plans that had already been obtained. The concern here was to find out whether in view of the weak competitive position of maize as a pure-stand crop in the major season, the changes in price would lead to basic changes in the cropping plans. The minimum selling prices used were ¢8.0, ¢10.0, ¢12.0, and ¢15.0 with other prices and resource levels held constant Phase I levels.[5] Table 7.1 summarizes the programmed results for Category I farm in Volta region and Category II farms in Brong-Ahafo, Ashanti, Eastern and Central region. Table 7.2 presents the range report to show the sensitivity of the optimum plans of the respective representative farms to changes in the price of maize.

The range report shows a lack of sensitivity of the optimum solution to maize price changes in Brong-Ahafo (0 to ¢8.0) and Volta region (0 to ¢12.85). However, in Brong-Ahafo at the price of ¢10.0 there was a change of the cropping plan with 5.8 acres allocated to minor season maize in pure-stand. Between ¢10.0 and ¢16.0 price changes did not affect the basis. In Ashanti, although there was a basic change in the optimum solution at the price of ¢10.0 , it was not until the price of maize had risen to ¢15.0 before further basic change occurred with 2.63 acres allocated to

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[5] In Phase II, seasonal selling and buying prices were used. The parametric price variations, therefore, relied on the Phase I model where annual average prices were used.

Table 7.1. Effects on Farm Organization and Income of Varying Maize Prices with Other Prices and Resources Held Constant.

Region	Activity/ Income	Unit	Maize Price in Cedis (¢)			
			¢8.00	¢10.00	¢12.00	¢15.00
Brong-Ahafo	Income	¢	5017	5240	5310	5935.7
	Activity:					
	MCPO	Acre	9.9	13.83	13.83	13.83
	MOYV	Acre	7.5	3.5	3.5	3.5
	Maize (Minor)	Acre	---	5.8	5.7	5.8
Ashanti	Income	¢	2058.2	2098.6	2139	2208
	Activity:					
	MCPOY	Acre	3.0	3.8	3.8	1.75
	MCPO	Acre				2.63
Eastern	Income	¢	1925	1968	2011	2074
	Activity:					
	MCOP	Acre	3.2	3.2	3.2	3.2
	Maize (Minor)	Acre	2.0	2.0	4.0	4.0
Central	Income	¢	2529	2584	2639.8	2721
	Activity:					
	MCY	Acre	3.9	3.9	3.9	3.9
	MCO	Acre	.02	.02	.02	.5
Volta	Income	¢	1220	1224	1228	1251
	Activity:					
	MCOYV	Acre	2.39	2.39	2.39	2.24
	Maize (Minor)	Acre				1.75

Legend
M = Maize
C = Cassava
P = Plantain
O = Cocoyam
Y = Yam
V = Pepper
¢ = Cedi (currency)

Source: Computed

maize. In the Central region, Eastern region and the Volta region, basic changes in the optimum solutions occurred beyond the price of ¢12.85 causing 2.0 acres more to be allocated to maize. However, in none of the situations did major season maize in pure-stand come into the solution space, a clear manifestation of the weak competitive position which maize in pure-stand holds in the major season. If the objective of using the guaranteed minimum price scheme is not only to ensure ready market for sellers of maize, but also to expand the output of maize relative to the other crops, a minimum price of ¢12.0 a bag would appear necessary.

Table 7.2. Price Ranges for Maize. Category II Farms.

Region	Price Ranges
Brong-Ahafo	0.0 to 8.0
Ashanti	3.46 to 9.69
Eastern	1.87 to 12.85
Central	1.71 to 12.85
Volta+	0.0 to 12.85

+For Category I Farms

Source: Computed

Input Prices: Subsidies[6]

In this section, we examine three inputs which during the time of the survey were being subsidized by the government, viz. fertilizers, weedicides and matchetes. In this year, the subsidy on matchetes has been withdrawn.

We shall be guided in our discussion by cost range reports which were part of the linear programming output of Phase II.[7] In the Central region, for instance, the program used 33.4 bags of fertilizers at an initial cost of ¢2.8 a bag--i.e., the subsidized price. The results show that the linear programming solution would remain optimal so long as the price of fertilizer stays between ¢0.0 and ¢17.18. In Brong-Ahafo, the program used 104.9 bags of fertilizers at an initial cost of ¢2.8 a bag. The range

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[6]The LP models in this study used variable inputs in fixed ratio to land. Theoretically, farmers will adjust the rate of inputs used as prices change. The type of adjustment of input use consequent upon price change would be different in the theoretical case from the actual situation modeled in this study. Therefore, care should be exercised in the interpretation of the range report.

[7]For a discussion of cost ranges, see Driebeck, 1969. The cost range shows the stability of the LP solution for changes in the cost of a single activity, keeping all other costs, technical coefficients, resources, etc., constant. The range report also shows what other or new activities would be selected at either the minimum or maximum cost. The range normally include the objective coefficient value of the relevant activity. Altering cost or price within the range can cause changes in the objective value even though the optimum plan or the operating strategy remains unchanged.

report further indicates that the linear programmed solution would also remain optimal so long as the price of fertilizer stays between ¢0.0 and ¢9.5. In Ashanti region, an amount of 54.8 bags was used with the price ranging between ¢0.0 and ¢25.6. Similarly, in the Eastern region, 32.9 bags were used with the price ranging from ¢0.0 to ¢28.0. To verify the stability of the LP solutions with regards to changes in fertilizer prices, three levels of fertilizer prices were used to determine their individual effects on the optimum solution: ¢3.6, ¢4.5 and ¢5.7. In each case, there was no change in the basis indicating that if fertilizer prices were raised to ¢5.6 a bag, the programming solution would remain optimal. The range reports indicate further that with the exception of Brong-Ahafo region, the optimum, various optimum plans were insensitive to fertilizer price changes. Increasing the cost of fertilizer to say ¢5.6 does not seem to suggest a different operating strategy even though the total income decreases with increases in fertilizer price.

As to the level of fertilizer price to suggest, the MVP per unit of fertilizer in the Phase II model is not a useful guide. With the elimination of the borrowing constraints in Phase II, all MVPs per unit of the inputs approximate their respective marginal cost. It follows that, if a fertilizer price of say ¢5.6 a bag had been used, the MVP per unit would have approximated ¢5.6. For

the three levels of fertilizer prices tested for Category II farms in Brong-Ahafo, viz. ¢3.6, ¢4.5 and ¢5.7 a bag each, the corresponding MVPs per unit of fertilizers were ¢3.75, ¢4.7 and ¢5.9, respectively. Furthermore, as indicated in a preceding footnote, the model used a fixed ratio of fertilizer to land planted to a given crop enterprise.

The implication is that if the farmers are loaned all the money needed and charged the full cost of fertilizer of about ¢13.0 a bag, they will still equate MVP with MFC. But, since the objective of the subsidy is to encourage fertilizer consumption, the government might as well leave the subsidy at its present level.

However, there are other distributional effects which the subsidy imposes that this study has not investigated. An example would be the income redistribution effect of across the board subsidized fertilizer prices.

An alternative guide to input pricing is to examine the MVPs per unit given in Table 5.4a, since the Phase I model depicts the actual constraints facing the farmers. Of the four regions, the MVPs of fertilizer, machetes and other inputs approximate their opportunity costs. In other regions, however, they are high.

With respect to herbicide, the current price of ¢6.0 a bag would have to fall to ¢3.6 a bag before it would be possible for crop enterprises, alternative technology 2, to come into the optimal solutions. The farmers interviewed

cited the price of herbicide as the major reason why they were not applying it. Thus both the model and the survey suggest a downward revision of the price of herbicide if the government wants to encourage its use.

Weeding, using manual labor, is a labor intensive farm operation whereas the use of herbicide to achieve the same purpose is rather a labor saving device. In Appendix Table B.2a the use of herbicide reduced labor hours used per acre in Phase II (column 2A) from 965 hours to 626.2 hours (column 3A). It is clear from the results that the application of this technology will reduce farm employment.

Farm Size Factor

As mentioned earlier, Ghanaian agriculture is composed predominantly of smallholders. An analysis of the 1970 census data, for instance, reveals that approximately 65 percent of the farmers operate less than 10 acres of which about 20 percent produce only for subsistence consumption, 50 percent produce a surplus for sale and 30 percent produce mainly for sale. With the exception of the representative farms in the Brong-Ahafo region, the sample data in this study are a true reflection of the conditions portrayed in the census survey. However, the earning power of the resources used by all the categories of farms in this study (i.e., their respective marginal value products) point to the great scope for enlarging the productive capacity of the farmers through resource expansion. According to

Johnson [1968], however, productive capacity is only a measure of potential ability to produce and is of little help in forecasting supply or predicting the amount actually produced and released to the market. He writes:

> ". . .forthcoming supplies depend on the degree to which actual price relationships permit producers to attain or exceed productive capacity" [Johnson, 1968].

The size sequence expansion options empirically verified in Chapter VI point to the income gains that can be attained (Tables 6.1 to 6.7 and Table 5.6, Chapter V). The income gains reported are only indicative of the potential that can be attained. They assume, for instance, that all the produce will be harvested. However, there are other aspects which this study has not investigated, viz., prices have a lot to do with how much of the crop the farmers havest and carry to the market for sale. This issue also needs further investigation as it is integrated with product, feeder roads, storage and distribution policies.

Summary

The agricultural economy of Ghana possesses vast potential for increasing agricultural output and associated employment. Presently, however, productivity is low and the state of agricultural technology has been relatively static even though the Ministry of Agriculture has invested in efforts to modernize farming in the country. Given this state of affairs,

a diagnostic study was needed to identify the small farmer problem and to provide some insights into efforts necessary for expanding the productive potentials of farms.

Accordingly, this study was desinged to focus attention on the following objectives:

1. Analysis of the organization of subsistence farming in the major maize growing areas so as to assess and appraise the economics of present resource use and the requisites for increasing agricultural output and farm incomes.
2. Determination of the efficiency of resource utilization and profit maximizing plans consistent with initial resource use and expanded resource use and technology of the categories of farming identified in the survey.
3. Evaluation of the potentials of the various policy instruments such as product and factor prices, rate of interest, on-farm storage, etc., which could be used to bridge the gap between actual and potential production and thus provide the framework for policy manipulations desired to achieve expanded food production and farm incomes in an optional fashion.
4. To determine alternative technological potentials of producing farm output, which can be considered by the extension workers in their innovation diffusion efforts.

5. To demonstrate the methodological reasonableness and efficiency of using linear programming techniques to examine the dynamics of on-farm storage of crop output with consideration given to consumption withdrawals for family subsistence needs.

Static linear programming and poly-period linear programming were used to assess the income increasing possibilities for the representative farms by an optimum allocation of the resources actually used by the farms in the sample. The representative farms were defined by the level of technology of production and by the ability to adopt agricultural innovations. Thus, two representative farms--traditional and transitional were defined for each geographic area. The analysis was repeated for three empirical phases and for all the five geographic areas located in five regions in the country, viz. Brong-Ahafo, Ashanti, Central, Eastern and Volta regions.

In the static linear programming model in Phase I, seven alternative resource situations were analyzed to determine the most feasible resource expansion. With the results of the Phase I model pointing to the large earning power not only of the most restrictive resource--money capital and land--but also the complementary inputs such as seeds, fertilizers, and simple farm implements, the model in Phase II allowed borrowing up to optimum levels instead of putting a restriction on the amount of money that could be

borrowed at the going rate of interest of 6 percent per annum. On-farm storage activities were also incorporated into the Phase II model. In Phases I and II, only those activities were included which were actually undertaken by the farmers of the sample of 1972-1973. In Phase III, however, parallel cropping activities representing two alternative advanced technologies of producing crops in pure-stand were introduced.

The remainder of this chapter will concentrate on the major findings, implications of the conclusions and suggestions for further research.

Conclusion

1. On both the transitional and indigenous farms, the marginal value products of land and capital were high, suggesting that increasing the use of these resources would lead to income gains. A great income raising possibility was also indicated by the marginal value products of agricultural inputs such as labor, fertilizers, planting materials, and farm implements used by the farmers. Generally, the pressure for increase in farm size is shown by the high MVP per acre of land in the study areas.

2. For all the categories of farms in the study areas, mixed-cropping had a comparative advantage over pure-stand cropping, as indicated by the shadow prices. The implication is that given the choice, the farmers would prefer growing crops in mixtures rather than in pure-stand, a fact that

militates against the introduction of new technology or enterprise specialization in the study areas. The advantage which mixed cropping held over pure-stand cropping was found to rest on the fact that new fertile land was continously being brought into cultivation. When there is no frontier of land, this advantage may disappear.

3. The analysis also points out that the starting point in a program to encourage farmers to increase resource use in the study area is the organization of adequate credit supply. This conclusion immediately follows: If the marginal value product per unit of capital is high, the formulation of credit policy should aim at providing credit to farmers taking into account expected returns, prodcution requirements and household consumption requirements as well. A credit policy based on productivity would be more effective than a policy based on security of loans. Farm planning, developed into an effective extension tool, would provide guidance to the institutional loaners.

4. Both labor use efficiency and income gains could be derived if thebottlenecks that to give way to under-utilization of both family and hired labor are removed. One policy option considered is the provision of a network of feeder roads. The cost and benefit aspects of this policy option, however, needs to be studied separately.

5. In view of the limited resources of the government to help farmers, additional efforts should be made to help

farmers maximize their incomes by organizing on-farm storage operations. Again, the benefit-cost aspect needs to be looked into as well as the macro-effect of storage on total village prices.

6. The cost range report indicated that the programmed solutions were insensitive to fertilizer and herbicide price changes. Theoretically, farmers will adjust the rate of input use as prices change, but since the model used inputs in fixed ratio to land (e.g., 4 bags of fertilizer per acre for a given enterprise) rate could be determined rather indirectly through changes in enterprise. The sensitivity analysis is, therefore, of little help in offering guidelines as to the price of fertilizer or herbicide to recommend.

However, within the framework of the current practice of recommending fertilizer use in fixed quantities to land, the sensitivity analysis has proved helpful in determining the enterprise or a combination of enterprises that would help maximize income. Despite the insensitivity of programmed solution to fertilizer price changes, it is recommended that the subsidy be maintained to encourage increased consumption of the input. The income distributional consequences of across the board fertilizer subsidy program needs investigation.

7. The parametric maize price analysis identified two levels of maize price which when applied to the study areas would encourage the farmers to plant pure-stand maize for

market, viz. ¢12.85 a bag in the Central, Eastern and Volta regions and ¢9.50 a bag in Ashanti and Brong-Ahafo regions. But, since it may not be administratively or politically feasible to maintain two levels of guaranteed minimum prices for maize in the country, a compromise price, fixed at ¢12.0 a bag applicable to all regions in the country might be tried.

Limitations and Suggestions For Future Research

Some limitations of this study must be noted. Linear programming models were used to assess the income increasing potentials of resources. The extent of income increase determined by the programmed results can be overstated because of the survey results used to derive the yield and price assumptions used in the models. The models also ignored stochastic factors such as weather variability which can affect the farmer's decision-making.

Another limitation of the study is the use of biological yields instead of actual yields in the model. This limitation can be avoided by extending the period of study to about four years to cover one full production cycle. However, we need to consider the benefit-cost of the two alternative approaches.

The models can be further used to investigate factor proportionality and derive more detailed responses to input price changes. The poly-period model which covered only one year divided into periods will need further extension so as to adequately investigate the dynamic interdependence between

production, consumption and investment over a period of say five years. The results also indicate what further activities and restrictions will need to be incorporated into the models. These activities will include activities that allow changes in technologies, and changes in the support prices for land clearing activities. Additional restrictions should be considered for seasonal labor to permit the incorporation into the model or work specialization by age and by sex.

Crop mixtures have been demonstrated in the study to hold comparative advantage over pure-stand crop enterprises using advanced technology. It is the belief of the author that the advantage which mixed-cropping now holds over pure-stand cropping is due to the availability of new frontier lands. In the long run, when shifting cultivation has pushed land to the extensive margin, the advantage alluded to will disappear. Both agronomic and socio-economic research is needed to investigate this long-run soil exhaustion argument.

The conclusion was reached that removing the bottlenecks that lead to labor utilization will increase labor use efficiency and farm income. It was suggested that a network of feeder roads to facilitate this is a feasible policy option. The cost and benefit analysis of the suggested program is needed.

This study also highlights the importance of collecting

input-output data in farm management research. Without a continuous supply of these basic data, it is impossible to formulate any programs dealing with farm planning in the dynamic agricultural economy of Ghana.

The Phase II model needs to be extended for a period of four years to adequately analyze storage delays for cocoyam, plantain and cassava--crops that undergo continuous harvesting. However, such a model will still be deficient in the absence of agronomic data dealing with the following special features of the crops:

1. The varying maturity dates of plantains of the same variety planted at the same time.
2. The time it takes for cassava and cocoyam to reach maturity beyond which date the root crops start undergoing deterioration.

It is suggested here that a combined LP model and simulaton of distributed delays of the type used in the Korean Sector Study [Johnson, et al., 1972] will be appropriate in analyzing the continuous harvesting of plantains, cocoyam and cassava crops.

APPENDICES

APPENDIX A

Table A.1. Sales, Consumption and Storage Activities for Maize.

Column Number	Activities	Column Name	Interacting Row	Coefficient
1	Buy maize Period 1	BMZ1	MZOP1*	-1
2	Consume maize Period 1	COMZ1	MZOP1	1
3		COMZ1	CMZ1	1
4	Buy maize Period 2	BMZ2	MZOP2	-1
5	Consume maize Period 2	COMZ2	MZOP2	1
6		COMZ2	CMZ2	1
7	Buy maize Period 3	BMZ3	MZOP3	-1
8	Consume maize Period 3	COMZ3	MZOP3	1
9		COMZ3	CMZ3	1
10	Sell maize Period 4	SMZ4	MZOP4	-1
11		SMZ4	CASHP4**	-5.4
12	Consume maize Period 4	COMZ4	MZOP4	1
13		COMZ4	CMZ4	1
14	Buy maize Period 4	BMZ4	MZOP4	-1
15		BMZ4	CASHP4	6.0
16	Store/transfer maize Period 4	MZTR4	MZOP4	1
17		MZTR4	MZOP5	- .973
18	Sell maize Period 5	SMZ5	MZOP5	1
19		SMZ5	CASHP5	-5.04
20	Consume maize Period 5	COMZ5	MZOP5	1
21		COMZ5	CMZ5	1
22	Buy maize Period 5	BMZ5	MZOP5	-1
23		BMZ5	CASHP5	5.64
24	Store/transfer maize Period 5	MZTR5	MZOP5	1
25		MZTR5	MZOP6	- .97
26	Sell maize Period 6	SMZ6	MZOP6	1
27		SMZ6	CASHP6	-6.4
28	Consume maize Period 6	COMZ6	MZOP6	1
29		COMZ6	CMZ6	1
30	Buy maize Period 6	BMZ6	MZOP6	-1
31		BMZ6	CASHP6	6.77
32	Store/transfer maize Period 6	MZTR6	MZOP6	1
33		MZTR6	MZOP7	- .989
34	Sell maize Period 7	SMZ7	MZOP7	1
35		SMZ7	CASHP7	-8.7
36	Consume maize Period 7	COMZ7	MZOP7	1
37		COMZ7	CMZ7	1
38	Buy maize Period 7	BMZ7	MZOP7	-1
39		BMZ7	CASHP7	9.7
40	Sell maize Period 7	SMZ77	MZOP77	1
41		SMZ77	CASHP7	-10.06
42	Consume maize Period 7	COMZ77	MZOP77	1
43		COMZ77	CMZ7	1
44	Buy maize Period 7	BMZ77	MZOP77	-1
45		BMZ77	CASHP7	10.06

*MZOP1,. . . ,MZOP7/MXOP77 : Maize inventory, Period 1,. . .,Period 7.

**CASHP1,. . .,CASHP7 : Cash at hand, Period 1,. . .,Period 7.

APPENDIX B

APPENDIX B

EXPLANATIONS OF TERMS USED IN TABLES B.1a TO B.4b

Table B.1a

LANDMI (Acre) Major season land in acres
LANDNI (Acre) Minor season land
LANDM2 (Acre) Unused land, major season in acres
LANDN2 (Acre) Unused land, minor season in acres
RENTLIMT (Acre) Maximum constraint for land renting--20 acres major season
RENTLINT (Acre) Maximum constraint for land renting minor season up to 10 acres
MZLIMT (Acre) Maximum maize acreage limit--20 acres
MAZLIMT (Acre) Minimum maize acreage limit, equal to initial acreage
CUSTOMH (Acre) Custom-hired machine services in major season
CUSTONH (Acre) Custom-hired machine services in minor season
CASHPI - - - CASHP2 (Cedi) Cash at hand period 1 to 7
CASH START (Cedi) Level of starting money capital
LABRPI - - - LABRP7 (Hour) Family labor in periods 1 to 7
LABRAM (Hour) Annual family labor
LABROFI - - - LABROF7 (Hour) Off-farm labor periods 1 to 7
LABROFAM (Hour) Annual off-farm labor availability

Table B.2a

STACHASHI (Cedi) Start cash in period 1
BORRWI - - - BORRW6 (Cedi) Borrow cash periods 1 to 6
CASDI - - - CASD6 (Cedi) Cash at hand periods 1 to 6
CLEARM (Acre) Clear unused major season land
CLEARN (Acre) Clear minor season land
REMTM (Acre) REnt major season land
REMTM (Acre) Rent minor season land
BWEED (Bag) Purchase weedicide
CUSTHIRM (Acre) Custom-hire machine in major season
CUSTHIRM (Acre) Custom-hire machine in minor season
BLABRI - - - BLABR7 (Hour) Hire labor periods 1 to 7
SLABRI - - - SLABR7 (Hour) Sell labor periods 1 to 7
SMZ4 (220 lbs) Sell maize period 4
MATR4 (220 lbs) Store maize period 4
SMZ5 (220 lbs) Sell maize period 5
MZTR5 (220 lbs) Store maize period 5

SMZ6 (220 lbs) Sell maize period 6
MZTR6 (220 lbs) Store maize period 6
SMZ7 (220 lbs) Sell maize period 7
SMZ77 (220 lbs) Sell minor season maize period 7
SMZVP4 (220 lbs) Sell maize as vegetable period 4
SMZVP7 (220 lbs) Sell maize as vegetable period 7
SCAS7 (200 lbs) Sell cassava period 7
SPLA7 (Bunch) Sell plantain period 7
SCOY6 (120 lbs) Sell cocoyam period 6
TCOYP6 (120 lbs) Store cocoyam period 6
SCOY7 (120 lbs) Sell cocyam period 7
SYAM6 (100) Sell yam period 6
TYAM6 (100) Store yam period 6
SVEG4 - - - SVEG7 (lbs) Sell pepper period 4, 5 and 6
TVEGH - - - TVEG6 (lbs) Store pepper period 4, 5 and 6
Maize (Acre) Maize output
M (Acre) Maize
C (Acre) Cassava
P (Acre) Plantain
O (Acre) Cocoyam
Y (Acre) Yam
V (Acre) Pepper
MZA2 (Acre) Maize output using recommended practices
MAZ3 (Acre) Maize output using recommended practices with weedicide
CASAI (Acre) Cassava output using recommended practices
CASA2 (Acre) Cassava output using recommended practices with weedicide
PLATAI (Acre) Plantain output using recommended practices
PLATA2 (Acre) Plantain output using recommended practices with weedicide
COYOAI (Acre) Cocoyam output using recommended practices
COYOA2 (Acre) Cocoyam output using recommended practices with weedicide
YAMAI (Acre) Yam output using recommended practices
YAMA2 (Acre) Yam output using recommended practices with weedicide
VEGAI (Acre) Pepper output using recommended practices
VEGA2 (Acre) Pepper output using recommended practices with weedicide

In Table B.1a the figures in brackets represent slack or unused resources.

In Table B.2a the figures in the column headed ‖ are the opportunity cost or the cost per unit of forcing in an activity not included in the basis (i.e., in the optimum plan).

Table B.1a. Marginal Value Products and Resource Level of Category II Farms, Brong-Ahafo Region, Ghana, 1972-73, Phases II and III.

Resource	Unit	Level	MVP	Level	MVP	Level	MVP	Level	MVP	Level	MVP
		2A		2B		2C		2D		3A	
LANDM1	Acre	17.3	393.7	17.3	423.1	17.3	393.8	17.3	393.8	17.3	393.7
LAMDN1	"	5.7	36.8	5.8	39.8	5.8	34.7	5.8	34.7	5.8	40.9
LANDM2	"	4	368.7	4.0	398.0	4.0	108.2	4.0	368.48	4.0	368.7
LANDN2	"	4	24.6	4.0	27.56	4.0	22.5	4.0	22.49	4.0	28.6
RENTLIMT	"					20.0	102.9	20.0	363.18		
RENTLINT	"					10.0	17.37	10.	17.37		
MAZLIMT	"					6.0	(14.0)				
MAZLIMG	"					6.0	371.8				
MZNLIMT	"					7.17	(2.83)				
MZNLIMG	"					7.17	(2.17)				
FERTILIZER	Lb		2.94		2.94		2.94		2.94		2.94
MATCHET	Single		.88		.88		.88		.88		.88
WEEDICIDE	Bag										6.26
CUSTOMH	Acre										14.2
CUSTONH	"										13.8
CASHP1	Cedis		.05		.05		.06		.06		.05
CASHP2	"		.05		.05		.05		.05		.05
CASHP3	"		.043		.04		.04		.04		.04
CASHP4	"		.03		.03		.03		.03		.03
CASHP5	"		.026		.026		.026		.02		.03
CASHP6	"										
CASHP7	"	250	.05	250	.05	250	.06	250	.06	250	.05
CASHSTART	"	1447	.139	1447	.092	1447	.14	1447	.14	1447	.14
LABRP1	Hour	735	.119	735	.079	735	.12	735	.12	735	.12
LABRP2	"	2189	.110	2189	.078	2189	.12	2139	.12	2189	.12
LABRP3	"	691	.127	691	.084	691	.13	691	.13	691	.13
LABRP4											

Table B.1a Continued

Resource	Unit	Level	MVP	Level	MVP	Level	MVP	Level	MVP	Level	MVP
		2A		2B		2C		2D		3A	
LABRP5	Hours	470	(232)	470	(232)	703	.06	703	.06	168.08	(534.9)
LABRP6	"	1397	.104	1397	.069	1397	.10	1397	.10	1397	.104
LABRP7	"	746	(585)	746	(585)	1245	(85.5)	1245	(85.5)	647.8	(683.2)
LABRA8V	"	7675	(817.6)	7675	(817.6)	8407.5	(85.5)	8407.5	(85.5)	7274	(1218)
LABROF1	"		(258)		(258)		(258)		(258)		(258)
LABROF2	"		(129)		(129)		(129)		(129)		(129)
LABROF3	"		(397)		(397)		(397)		(397)		(397)
LABROF4	"		(129)		(129)		(129)		(129)		(129)
LABROF5	"	129	.062	129	.062	11.05	(117.9)	11.05	(117.9)	129	.06
LABROF6	"		(257)		(257)		(257)		(257)		(257)
LABROF7	"	257	.06	257	.06	257	.06	257	.06	257	.06
LABROFAN	"	386	(1169)	386	(1169)	268.05	(1286.9)	268.05	(1286.3)	386	(1169)
GROSS REVENUE	(c)	9,310.01		9,696.84		8,285.42		16,762.27		9,349.01	
TOTAL ACRES	AC	31.07		31.07		61.11		61.11		31.07	
AMT HIRED LABR	Hour	14,772		9,250		22,420		37,893		14,372	
AMOUNT BORROWED	(c)	1,580.89		1,302.27		3,018.49		4,424.34		1,666.36	
RETURN/ACRE	(c)	300.23		312.10		135.58		274.30		300.90	
RETURN/MAF HR.	(c)	.41		.57		.27		.36		.43	
RETURN/CAPITAL		5.08		6.25		2.53		3.58		4.88	
LAB HRS/ACRE	Hour	722.0		545.0		504.0		758.		697.0	
AMT BORROWED/ACRE	(c)	50.88		41.91		49.39		72.39		53.63	
RATIO OF HIRED LABOR TO TOTAL LABOR INPUT	%	65.81%		54.65		72.72%		81.84%		66.4%	

Source: Computed.

( ) slack values.

Table B.1b. Summary of Optimum Farm Plans Under Variable Resource Level (Phases II and III), Category II Farms, Brong-Ahafo Region, Ghana, 1972-73.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
STACASH1	Cedis	250		250		250		250		250	
BORRW1	"		.0086		.0086	708.87		702.87			.0086
CASD1	"	73.2		107.82			.0086		.0086	93.21	
BORRW2	"	1147.2		1023.29		1537.79		2480.05		1100.79	
CASD2	"		.0086		.0086		.0086		.0086		.0086
BORRW3	"	325.3		225.96		547.07		832.06		325.25	
CASD3	"		.008		.0086		.0086		.0086		.0086
BORRW4	"	59.24		4.23		5.53		184.13		59.24	
CASD4	"		.008		.0086		.0086		.0086		.0086
BORRW5		49.15		49.15		225.23		225.23		181.08	
CASD5	"		.0257		.0257		.0257		.0257		.0257
BORRW6	"		.0171		.0171		.0171		.0171		.0171
CASD6		3223.78		3319.90		2721.78		6113.49		3251.28	
CLEARM	Acre	4.0		4.0		24.0		24.0		4.0	
CLEARN	"	4.0		4.0		14.0		14.0		4.0	
RENTM	"					20.0					
RENTN	"					10.0					
BWEED	Bag										
CUSTHIRM	Acre										
CUSTHIRN	"									9.77	
BLABR1	Hour	491.2		324.22		3006.39		3006.39		491.24	
BLABR2	"	4286.		2328.78		4717.54		9346.64		4286.03	
BLABR3	"	3893.6		2569.82		6851.24		10651.24		3893.66	
BLABR4		1992.4		1314.96		3148.12		4840.85		1992.36	
BLABR5	"		.0832		.0833		.0427		.0427		.0833
BLABR6											

Table B.1b Continued

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
BLABR7	Hours		.068		.0688		.0689		.0688		.0688
SLABR1	"		.076		.0289		.0769		.0769		.07631
SLABR2	"		.0563		.0158		.0564		.0564		.0564
SLABR3	"		.0559		.0156		.0559		.0559		.0559
SLABR4	"		.0652		.0219		.0658		.0658		.0652
SLABR5		129		129		11.05		11.05		129.0	
SLABR6	"		.0442		.0088		.0442		.0442		.0442
SLABR7	"	257		257		257		257		257	
SMZ4	"		2.56		2.56		2.56		2.56		2.56
MZTR4	220 Lb	119.4		119.4		274.74		231.42		119.42	
SMZ5	"		3.2		3.2		3.2		3.2		3.2
MZTR5		116.11		116.11		267.24		225.09		116.11	
SMZ6	"		2.2		2.24		2.24		2.24		2.24
MZTR6	"	112.48		112.48		259.07		218.19		112.48	
SMZ7	"	111.1		111.10		256.08		215.64		111.10	
SMZ77	"	50.8		50.80		102.80		102.80		63.50	
SMZVP4	"	11.85		11.86		27.39		23.06		11.86	
SMZV7	"	5.01		5.01		10.21		10.21		1.88	
SCAS7	200 Lb		.39		.39		.39		.39		.39
SPLA7	Bunch		.058		.058		.058		.058		.058
SCOY6	120 Lb	414.93		414.93		360.38		804.53		414.93	
TCOYP6	"		.48		.48		.48		.48		.48
SCOY7	"		.62		.62		.62		.62		.62
SYAM6	100		10.53		10.53		10.53		10.53		10.53
TYAM6	"	223.88		223.88		194.48		433.88		233.88	
SYAM7	"	208.05		208.05		180.71		403.35		208.05	
SVEG4	Lb		.013		.013		.013		.013		.013

Table B.1b Continued

Resource			Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
				2A		2B		2C		2D		3A	
TVEG4			Lb	6951.8		6951.8		6039.04		13471.84		6951.8	
SVEG5			"		.016		.016		.016		.016		.016
TVEG5			"	6759.14		6759.14		5870.99		13103.10		6759.14	
SVEG6			"	6157.18		6157.18		5345.41		11955.56		6157.18	
TVEG6			"	10.67		10.67		10.67		10.67		10.67	
SVEG7					.002		.002		.002		.002		.002
PPING:	1	Maize	AC		371.8		389.28	22.80			371.73		371.79
	2	MY	"		67.3		75.87		67.32		67.32		67.32
	3	MCY	"				67.74						62.50
	4	MCPO	"				96.40		45.43		23.07		19.98
	5	MOYV		21.3		21.34		18.54		41.34		21.34	
	6	MCOV	"		150.6		219.68		150.55		150.55		216.34
	7	MCPYV					57.91		20.13				
	8	MAIZEN	"	9.77		9.77		19.77		19.77			3.99
	9	MZA2											361.13
	10	MZA	"										497.8
	11	CASA1											119.45
	12	CASA2	"										122.26
	13	PLATA1	"										130.18
	14	PLATA2	"										129.07
	15	COYOA1	"										107.79
	16	COYOA2											110.50
	17	YAMA1	"										33.21
	18	YAMA2	"										23.95
	19	VEGA1	"										6.17
	20	VEGA2	"										23.33
	21	MZNA1	"									9.77	
	22	MZNA2											8.05

Source: Computed

Table B.2a. Marginal Value Products and Resource Level of Category II Farms, Ashanti Region, Ghana, 1972-73, Phase I and II (Cedis ¢).

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
LANDM1	Acre	6.2	446.76	6.2	488.8	6.2	446.76	6.2	446.76	6.2	453.6
LANDN1	"	2.0	85.23	2.0	94.12	2.0	93.63	2.0	85.23	2.0	87.29
LANDM2	"	6.0	421.53	6.0	463.58	6.0	131.05	6.0	421.53	6.0	428.37
LANDN2	"	"	(2.00)	"	(2.00)	"	(2.00)	"	(2.00)	"	(2.00)
RENTLIMT	"					20	125.76	20	416.23		
RENTLINT							(10.00)		(10.0)		
MAZLIMT	"					6.0	(14.0)				
MAZLIMG	"					6.0	44.96				
MZNLIMT						2.0	(8.0)				
MZNLIMG	"					2.0	55.96				
FERTILIZER	Lb		2.94		2.94		2.94		2.94		2.94
MATCHET	Single		.88		.88		.88		.88		.88
WEEDICIDE	Bag									"	5.01
CUSTOMH	Acre									"	14.19
CUSTONH	"									"	18.76
CASHP1	Cedi	.05	.06	.06	.06	.06	.06	.06	.06	.06	.06
CASHP2	"	.05	.05	.05	.05	.05	.05		.05		.05
CASHP3	"		.04		.04		.04		.04		.04
CASHP4	"		.00		.00		.00		.00		.00
CASHP5	"		.00		.00		.00		.00		.00
CASHP6			.00		.00		.00		.00		.00
CASHP7	"		0		0		.00		0		)
CASHSTART	"	125.19	.06	125.19	.06	125.19	.06	125.19	.06	125.19	.06
LABRP1	Hour	720	.18	720	.12	720.0	.18	720	.18	660.83	(59.16)
LABRP2	"	384	.15	384	.09	384	.15	384	.15	384	.15
LABRP3	"	1,089	.17	1,089	.11	1,089	.17	1,089	.17	1,089	.17
LABRP4	"	333	.11	333	.09	333	.14	333	.14	262.5	(70.5)

Table B.2a Continued.

Resources	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
LABRP5	Hour	264	(84.0)	264	(84.0)	264	(84.0)	264	(84.0)	264	(84.0)
LABRP6	"	669	.14	669	.09	669	.14	669	.14	669	.14
LABRP7	"	591	.14	591	.09	591	.14	591	.14	591	.13
LABRASV		4,050	(84.0)	4,050	(84.0)	4,050	(84.0)	4,050	(84.0)	3,930.33	(213.66)
LABROF1	"		(196)		(196)		(196)		(196)	176	.06
LABROF2	"		(98)		(98)		(98)		(98)	98	.06
LABROF3	"		(294)		(294)		(294)		(294)		(294)
LABROF4			(98)		(98)		(98)		(98)	98	.06
LABROF5	"	196	.06	196	.06	196	.06	196	.06	196	.06
LABROF6	"		(196)		(196)		(196)		(196)		(196)
LABROF7	"		(196)		(196)		(196)		(196)		(196)
LABROFAN		196	(1,085)	196	(1,085)	196	(1,085)	196	(1,085)	588	(693)
ROSS REVENUE	(c)	5,900.84		6,228.87		4,088.12		14,225.41		5,946.00	
TOTAL ACRES	AC	14.2		14.2		34.2		34.2		14.2	
AMT HIRED LABR	Hour	9,647.0		6,365.		12,399		33,940		4,972	
AMOUNT BORROWED	(c)	1,219.43		1,013.08		2,240.9		4,131.67		937.06	
RETURN/ACRE	(c)	415.55		438.65		119.54		415.95		418.43	
RETURN/MAN HR.	(c)	.43		.60		.25		.37		.66	
RETURN/CAPITAL	(c)	4.39		5.47		1.73		3.34		5.59	
HRS/ACRE	Hour	965.0		733.0		480.96		1,111.00		626.20	
AMOUNT BORROWED PER ACRE	(c)	85.88		71.34		65.68		120.81		65.99	
RATIO OF HIRED LABOR TO TOTAL	%	70.43%		61.11%		75.38%		89.34%		55.92%	

Source: Computed

* ( ) represents slack values

Table B.2b. A Summary of Optimum Farm Plans Under Variable Resource Level (Phases II and III). Category II Farms, Ashanti Region, Ghana, 1972-73.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	
		2A		2B		2C		2D		3A	
STACASH1	Cedis	125.19		125.19		125.19		125.19		125.19	
BORRW1	"	51.63		49.52		840		840		33.66	
CASD1	"		.0086		.0086		.0086		.0086		.0086
BORRW2	"	854.2		738.36		906.7		2265		798.90	
CASD2			.0086		.0086		.0086		.0086		.0086
BORRW3	"	313.6		225.2		494.2		1026.67		104.5	
CASD3	"		.043		.043		.043		.043		
BORRW4	"		.034		.034		.034		.034		.034
CASD4	"	43.2		44.8		35.9		67.01		13.60	
BORRW5	"		.026		.025		.026		.026		.026
CASD5		42.1		43.7		34.8		65.8		12.44	
BORRW6	"		.017		.017		.017		.017		.017
CASD6	"	1,572.7		1620.8		1049.6		4001.20		694.18	
CLEARM	Acre	6.0		6.0		26.		26.0		6.0	
CLEARM	"		97.1		106.1		155.9		97.1		99.19
RENTM	"					20.0		20.0			
RENTN	"						5.0		5.0		1.24
BWEED	Bag									6.72	
CUSTHIRM	Acre										
CUSTHIRN	"										32.26
BLABR1	Hours	55		36		1934		1934			.119
BLABR2	"	3633		2397		3098		10541		3542	
BLABR3	"	2454		1619		4157		9181		481	
BLABR4	"	50		33		1510		951			.093
BLABR5	"		.10		.10		.10		.10		.10
BLABR6	"	1458		962		777		5245		949	

Table B.2b. Continued.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
BLABR7	Hours	1997		1318		923		6088			.01036
SLABR1	"		.117		.0117		.117		.117	196	
SLABR2	"		.118		.055		.118		.118	98	
SLABR3	"		.105		.048		.105		.105		.105
SLABR4	"		.082		.034		.082		.082	98	
SLABR5	"	196		196		196		196		196	
SLABR6	"		.082		.034		.082		.082		.082
SLABR7	"		.082		.034		.082		.082		.066
SMZ4			4.7		4.7		4.7		4.7		4.7
MZTR4	220 Lb	68		68		206.7		179.6		27.5	
SMZ5	"		5.6		5.6		5.6		5.6		5.6
MZTR5	"	66.1		66		201.1		174.7		26.69	
SMZ6	"		3.2		3.2		3.2		3.2		3.2
MZTR6	"	62.2		62.2		189.4		164.57		25.01	
SMZ7	"	57.9		57.9		176.9		153.55		23.37	
SMZ77	"	10.2		10.2		10.3		10.2		10.05	
SMZVP4	"	6.986		6.986		20.7		18.5		2.7	
SMZV7	"	.95		.95		.97		.95		.95	
SCAS7	200 Lb	243.4		243.1		159.4		643.43			.60
SPLA7	Bunch	3520		3520		2302		9319.6		1638	
SCOY6	120 Lb	243.1		243.1		159		643.08		113.13	
TCOYP6	"		.57		.57		.57		.57		.57
SCOY7	"		.33		.33		.33		.33		.33
SYAM6	100		5.5		5.5		5.5		5.5		5.5
TYAM6	"	121.7		121.7		79.7		321.7		130.86	
SYAM7	"	113.0		113.0		73.9		298.96		177.24	
SVEG4	Lb		.05		.05		.05		.05		.05

Table B.2b Continued.

Resource		Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
			2A		2B		2C		2D		3A	
TVEG4		Lbs	16.4		16.4		16.4		16.4		16.4	
SVEG5		"		.04		.04		.04		.04		.04
TVEG5		"	10.94		10.94		10.94		10.94		10.94	
SVEG6		"		.037		.037		.037		.037		.037
TVEG6		"		.026		.026		.008		.026		.026
SVEG7		"	830.0		830			.02	830		830	
OPPING:	1 Maize	AC		414.9		444.9	24.2			415		404.21
	2 MC	"		377.8		403.4		377.8		377.8		329.80
	3 MY	"		362.		388.3		362		362		337.90
	4 MY	"		85.76		106.7		85.8		85.8		76.43
	5 MCY	"		138.9		152.2		138.9		138.9		100.92
	6 MCPO	"		204.04		215.1		204		204		169.32
	7 MCTV	"		113.9		118.03		113.9		113.9		63.59
	8 MCOY	"		55.1		59.7		55.1		55.1		
	9 MPOY			9.6		15.1		9.6		9.6	5.48	
	10 MCPOY	"	12.2		12.2		8.0		32.2			41.05
	11 MCPOY	"		210.9		217.1		210.9		210.9		168.91
	12 Maize (Minor)			47.56		49.15	2.0			47.6		48.68
	13 MV (Minor)	"	2.0		2				2.0		2.0	
	14 MZA2											395.9
	15 MZA3	"										572.13
	16 CASA1	"										292.14
	17 CASA2	"										288.8
	18 PLATA1	"										420.34
	19 PLATA2	"										411.11
	20 COYOA1											108.71
	21 COYOA2	"										105.36
	22 YAMA1	"									6.7	
	23 YAMA2											124.68
	24 VEGA1	"										126.32
	25 VEGA2											4.24
	26 MZNA1	"										
	27 MZNA2											

Source: Computed.

Table B.3a. Marginal Value Products and Resource Level of Category II Farms Eastern Region, Ghana, 1972-73 (Phases II and III).

Resources	Unit	Level	MVP	Level	MVP	Level	MVP	Level	MVP	Level	MVP
		2A		2B		2C		2D		3A	
LANDM1	Acre	3.22	529.7	3.22	545.5	3.22	505.3	3.22	498.3	3.22	529.8
LANDN1	"	2	62.7	2	66.2	2.0	62.7	2	59.4	2.0	66.5
LANDM2	"	4.0	504.7	520.5		4.0	139.9	4	473.1	4	504.7
LANDN2	"	Slack	(2)	Slack	(2)	Slack	(2)	Slack	(2)	Slack	(2)
RENTLIMT	"					20	134.6	20	467.8		
RENTLINT	"					Slack	(10)	Slack	(10)		
MAZLIMT	"					3.22	(Slack)				
MAZLIMG	"					3.22	486.04				
MZNLIMT	"					2	(8)				
MZNLIMG	"					Slack	(2)				
FERTILIZER	Lb		2.94		2.94		2.94		2.94		2.94
MATCHET	Single		.883		.883		.883		.883		.883
WEEDICIDE	Bag										6.26
CUSTOMH	Acre										14.2
CUSTONH	"										13.5
CASHP1	Cedi		.051		.051		.051		.05		.051
CASHP2	"		.051		.051		.051		.051		.051
CASHP3	"		.043		.043		.043		.043		.043
CASHP4											
CASHP5											
CASHP6	"										
CASHP7	"										
CASHS7ART											
LABRP1	Hour	125.02	.051	125	.051	125	.06	125	.06	125	.05142
LABRP2	"	628	.06	628	.06	628	.18	628	.18	628	.063
		432	.149	432	.099	432	.14	432	.15	432	.15
LABRP3	"	1323	.063	1323	.063	1323	.167	1323	.17	1323	.063
LABRP4	"	393	.06	393	.060	393	.142	393	.14	393	.06

Table B.3a. Continued

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
LABRP5	Hour	203	(221)	203	(221)	203	(221)	203	(221)	125	(299)
LABRP6	"	746	.142	746	.094	746	.142	746	.42	746	.142
LABRP7	"	702	.06	702	.06	702	.06	702	.142	702	.06
LABRA8V	"	4429	(219)	4429	(219)	4429	(219)	4429	219	4349	(299)
LABROF1	"	172	(62)	172	(62)	Slack	(234)	Slack	234	234	
LABROF2	"	117	"	117	"	Slack	(117)	Slack	117	55	(62)
LABROF3	"	243	(107)	243	(107)	Slack	(351)	Slack	351	244	(107)
LABROF4	"	104	(13)	104	(13)	Slack	(117)	Slack	117	104	(13)
LABROF5	"	117	.06	117	.06	117	.06	117	.06	177	.06
LABROF6	"		(234)		(234)	Slack	(234)	Slack	(234)	Slack	(234)
LABROF7	"	6	(228)	6	(228)	7	(227)	Slack	(234)	6	(228)
LABROFAN	"	759	(645)	759	(645)	124	(1280)	117	(1287)	759	(645)
GROSS REVENUE	(c)	4051.77		4115.40		3885.21		3476.66		4059.40	
TOTAL ACRES	AC	9.224		9.224		29.206		29.244		9.224	
AMT HIRED LABR	Hour	1927		1271		6921		17690		1839	
AMOUNT BORROWED	(c)	377.8		355.5		1625.7		2634.29		368.9	
RETURN/ACRE	"	439.26		446.12		133.02		460.84		440.09	
RETURN/MAN HR	"	.64		.72		.34		.61		.66	
RETURN/CAPITAL	"	8.02		8.94		2.22		4.88		8.21	
LAB HRS/ACRE	Hour	689		618		300.62		756		671	
AMT BORROWED/ACRE	(c)	40.88		36.37		55.66		90.08		40.0	
RATIO OF HIRED TO TOTAL LABOR INPUTS	%	30%		61%		61%		79.98		29.72	

Source: Computed

( ) represents slack values

Table B.3b. A Summary of Optimum Farm Plans Under Variable Resource Level (Phases II and III). Category II Farms, Eastern Region, Ghana, 1972-73.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
STACASH1	Cedis	125.0		125.0		125.0		125.0		125.0	
BORRW1	"		.0086		.0086	685.2		685.2			.0086
CASD1	"	12.1		12.1			.0086		.0086	15.8	
BORRW2	"	350.9		308.6		668.5		1468.1		342.0	
CASD2	"		.009		.0086		.0086		.0086		.0086
BORRW3	"	26.9		26.9		272		480.99		26.94	
CASD3			.043		.043		.043		.043		.043
BORRW4	"		.043		.043		.043		.043		.043
CASD4	"	360.9		360.9		1521.2		1283		360.9	
BORRW5	"		.026		.026		.026		.026		.026
CASD5		349.1		349.2		1509.4		1271.4		322	
BORRW6	"		.0171		.0171		.017		.017		.017
CASD6	"	281.2		300.4		1441.9		819.7		262.5	
CLEARM	Acre	4.0		4.0		24.0		24		4.0	
CLFARN	"		74.6		78.6		74.58		71.3		
RENTM	"					20.0		20			
RENTN	"						5.0		5.0		
BWEED	Bag										4.0
CUSTHIRM	Acre										
CUSTHIRN	"									2.0	
BLABR1	Hour		.074		.055	987		987			.077
BLABR2	"	1326		875		2199		6811		1326	
BLABR3	"		.07		.048	2174		4146			.07
BLABR4	"		.054		.034	1054		1054			.054
BLABR5	"		.10		.10			.10			.10
BLABR6	"	601.0		396		597		4692		513	

Table B.3b Continued

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
BLABR7	Hour		.054		.034		.054	2567			.054
SLABR1	"	171.7		171.7	.118		.118		.118	234	
SLABR2	"	117.0		117.0			.118		.118	55	
SLABR3	"	244		244			.105		.105	244	
SLABR4	"	104		104			.082		.082	104	
SLABR5	"	117		117		117		117		117	
SLABR6	"		.082		.034		.082		.082		.082
SLABR7	"	6.0		6.0		7.0			.082	6.0	
SMZ4	220 Lb	39.5		39.5		174.9		149.5		39.5	
MZTR4	"		22.3		22.3		22.3		22.3		22.3
SMZ5	"		5.06		5.06		5.06		5.06		5.06
MZTR5	"	.28		.28		.28		.28		.28	
SMZ6	"		3.38		3.38		3.38		3.38		3.38
MZTR6	"		.22		.21						
SMZ7	"		.36		.36		.58		.56		.58
SMZ77	"	11.14		11.14		11.14		11.14		12.74	
SMZVP4	"	3.88		3.88		17.5		14.9		3.9	
SMZV7	"	1.07		1.07		1.07		1.07		.33	
SCAS7	200 Lb	231.97		231.97		231.3		877.2		231.97	
SPLA7	Bunch		.063		.063		.101		.125		.063
SCOY6	120 Lb		1.82		1.82		1.82		1.82		1.82
TCOYP6	"	207.2		207.2		206.6		785.2		207.2	
SCOY7	"	191.5		191.5		190.97		729.04		191.5	
SYAM6	100		7.05		7.05		7.05		7.05		7.05
TYAM6	"	49.6		49.6		49.4		187.4		49.6	
SYAM7	"	45.998		45.998		45.87		174.15		45.998	
SVEG4	Lb		.05		.05		.05		.05		.05

Table B.3b Continued.

Resource		Unit	Level II	Level II	Level II	Level II	Level II
			2A	2B	2C	2D	3A
TVEG4		Lbs	5.82	5.82	5.82	5.82	5.82
SVEG5		"	.044	.044	.044	.044	.044
TVEG5		"	.008	.008	.008	.008	.008
SVEG6		"	.03	.03	.03	.03	.03
TVEG6		"	.01	.01	.01	.01	.01
SVEG7		"	.02	.02	.02	.02	.02
CROPPING:	1 MZM	Acre	492.8	507.3	20.02	479.06	492.9
	2 MCO	"	224.2	233.8	226.2	226.6	224.2
	3 MCPYV	"	317.7	331.2	322.4	257.7	317.7
	4 MCOV	"	199.3	208.5	208.1	143.1	119.3
	5 MCOY		7.18	7.18	7.16	27.2	7.18
	6 MCPY	"	83.97	87.49	78.4	78.4	83.97
	7 MCPYV	"	76.5	75.56	81.3	22.6	76.5
	8 MCPOY	"	.044	.044	.044	.044	.044
	9 MCPOYV		33.69	28.98	40.1		33.69
	10 MZN	"	2.0	2.0	2.0	2.0	3.81
	11 MZA2	"					490.5
	12 MZA3						632.9
	13 CASA1						278.8
	14 CASA2	"					285.8
	15 PLATA1						389.8
	16 PLATA2	"					394.7
	17 COYOA1	"					125.7
	18 COYOA2						132.7
	19 YAMA1						103.3
	20 YAMA2	"					111.5
	21 VEGA1	"					121.8
	22 VEGA2	"					148.2
	23 MZNA1						2.0
	24 MZNA2						6.72

Source: Computed.

Table B.4a. Marginal Value Products and Resource Level of Category II Farms Central Region, Ghana, 1972-73 (Cedis (¢)).

Resource	Unit	Level	MVP	Level	MVP	Level	MVP	Level	MVP	Level	MVP
		2A		2B		2C		2D		3A	
LANDM1	Acre	4.97	513.34	4.97	540.96	4.97	498.69	4.97	498.69	4.97	513.34
LANDM1	"	2.0	52.18	2.0	61.97	2.00	47.76	2.00	47.76	2.00	60.38
LANDM2	"	3.51	488.1	3.51	515.74	3.51	155.48	3.51	473.46	3.51	488.1
LANDN2	"	2.0	39.97	2.0	49.76	2.0	35.56	2.0	35.56	2.0	48.18
RENTLIMT	"					20.0	**150.18**	20.0	468.16		
RENTLINT	"					10.0	30.43	10.0	30.43		
MAZLIMT	"					4.97	(15.03)				
MAZLIMG	"					4.97	454.86				
MZNLIMT	"					3.2	(6.8)				
MZNLIMG	"					3.2	(1.2)				
FERTILIZER	Lb		2.94		2.94		2.94		2.94		2.94
MATCHET	"		.88		.88		.88		.88		.88
WEEDICIDE	Bag										3.59
CUSTOMH	Acre										14.19
CUSTONH	"										13.85
CASHP1	Cedi		.06		.06		.06		.06		.06
CASHP2	"		.05		.05		.05		.05		.05
CASHP3	"		.04		.04		.04		.04		.04
CASHP4	"		.03		.03		.03		.03		.03
CASHP5			.03		.03		.03		.03		.03
CASHP6	"		.09		.02		.02		.02		.02
CASHP7	"		.00		.00		.00				
CASHSTART	"	74.61	.06	74.61	.06	74.61	.06	74.61	.06	74.61	.06
LABRP1	Hour	546	.06	546	.06	546	.04	546	.04	546	.06
LABRP2	"	297	**.15**	297	.09	297	.007	297	.007	297	.15
LABRP3	"	875	.06	875	.06	875	.03	875	.03	875	.05
LABRP4	"	274	.15	874	.09	271	.005	274	.005	274	.13

Table B.4a Continued

Resource	Unit	Level	MVP	Level	MVP	Level	MVP	Level	MVP	Level	MVP
		2A		2B		2C		2D		3A	
LABRP5	Hour	251	.06	251	.06	251	.013	251	.013	97	(154)
LABRP6	"	509	.14	509	(V)	509	.002	509	.002	509	.14
LABRP7	"	426	.14	426	.09	426	(V)	426	(V)	426	.14
LABRASV	"	3178	(V)	3178		3178	.14	3178	.14	3024	(154)
LABROF1	"	147.44	(14.56)	147.44	(14.56)		(162)		(162)	147.44	(14.56)
LABROF2	"		(81.0)		(81.0)		(81)		(81)		(81)
LABROF3	"	137.24	(105.76)	137.24	(105.76)		(243)		(243)	137.24	(105.76)
LABROF4	"		(81.01)		(81.0)		(81.)		(81)		(81)
LABROF5	"	63.0	(18.0)	63.0	(18.0)		(81)		(81)	81	.05
LABROF6	"		(168.0)	162	.06		(162)		(162)		(163)
LABROF7	"		(162.0)		(162)		(162)		(162)		(162)
LABROFAN	"	347.68	(624.32)	509.63	(462.32)		(972)		(972)	365.68	(606.32)
BORROWING	"										
ROSS REVENUE	(c)	4675.45		4835.94		4647.28		14380.65		4697.82	
TOTAL ACRES	"	12.48		12.48		42.48		42.48		12.48	
AMT HIRED LABR	Hours	3532		1317		11,289		21,580		3,459	
AMOUNT BORROWED	(c)	582.86		455.13		2,255.31		3,348.91		620.79	
RETURN/ACRE	(c)	374.64		387.50		109.40		338.53		376.43	
RETURN/MAN HR.	(c)	.70		1.06		.32		.58		.72	
RETURN/CAPITAL	(c)	7.12		9.13		1.99		4.2		6.75	
HRS/ACRE	Hours	538		365		341		583		519	
AMT BORROWED /ACRE	(c)	46.70		36.47		53.08		78.83		49.74	
RATIO OF HIRED TO	"										
TOTAL LABOR INPUTS	"	52.64%		28.95		78.0%		87.16%		53.35	

Source: Computed.

Table B.4b. Summary of Optimum Farm Plans Under Variable Resource Level (Phases II and III), Category II Farms, Central Region, Ghana, 1972-73.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
STACASH1	Cedis	74.6	Cedis	74.6	Cedis	74.6	Cedis	74.6	Cedis	74.6	Cedis
BORRW1	"	15.4		15.4		735.38		735.38		15.43	
CASD1	"		.009		.009		.009		.009		.009
BORRW2	"	474.14		416.79		853.7		1,682.17		455.14	
CASD2	"		.009		.009		.009		.009		.009
BORRW3	"	15.99		15.99		271.31		381.63		15.99	
CASD3	"		.017		.017		.009		.009		.017
BORRW4	"		.009		.009	18.97		30.16			.009
CASD4	"	12.17		21.47			.009		.009	12.17	
BORRW5	"	13.96		4.66		260.58		260.58		66.88	
CASD5	"		.009		.009		.009		.009		.009
BORRW6	"	63.37		2.29		115.37		358.99		67.35	
CASD6	"		.017		.017		.017		.017		.017
CASD7	"					23.51		23.51		3.5	
CLEARM	Acre	3.5		3.5							
CLEARN	"	2.0		2.0		12.00		12.00		2.0	
RENTN	"					20.00		20.00			
RENTN	"					10.00		10.00			
BWEED	Bag										2.66
CUSTHIRM	Acre										
CUSTHIRN	"									4.0	
BLABR1	Hours		.077		.056	1,200.85		1,200.85			.077
BLABR2	"	1,798.48		1,187.0		2,523.93		7,101.52		1,798.48	
BLABR3	"		.069		.048	2,331.03		2,428.42			.069
BLABR4	"	291.51		192.4		1,925.72		1,958.18		291.52	
BLABR5	"		.069		.041	616.67		616.67			.133
BLABR6	"	547.58		523.4		1,101.88		3,699.09		590.0	

Table B.4b Continued.

Resource	Unit	Level	II	Level	II	Level	II	Level	II	Level	II
		2A		2B		2C		2D		3A	
BLABR7	Hour	894.18	Cedis	590.16	Cedis	1,589.21	Cedis	4,576.	Cedis	779.03	Cedis
SLABR1	"	147.44		147.44			.117		.117		
SLABR2	"		.0005		.0005		.117		.117		.0005
SLABR3	"	137.24		137.24			.105		.105	137.24	
SLABR4	"		.084		.035		.085		.085		.084
SLABR5	"	63.0		63.0			.094		.094	81.00	
SLABR6	"		.083	162.0			.084		.084		.083
SLABR7	"		.082		.034		.082		.082		.082
SMZ4	"		4.77		4.77		4.69		4.69		4.76
MZTR4	220 Lb	47.35		47.35		176.49		159.35		47.35	
SMZ5	"		4.26		4.26		4.26		4.26		4.26
MZTR5	"	45.93		45.93		171.59		154.91		45.93	
SMZ6	"		2.61		2.61		2.61		2.61		2.61
MZTR6	"	44.42		44.42		166.68		150.45		44.42	
SMZ7	"	43.93		43.93		164.85		148.52		43.93	
SMZ77	"	21.32		21.32		75.32		75.6		25.72	
SMZVP4	"	4.99		4.99		17.86		16.99		4.99	
SMZV7	"	2.09		2.09		7.49		7.49		.73	
SCAS7	200 Lb	355.36		355.36		295.43		1,195.36		355.36	
SPLA7	Bunch		.14		.14		.14		.14		.14
SCOY6	120 Lb		4.07		4.07		4.07		4.07		4.07
TCOYP6	"		1.62		1.62		1.62		1.62		1.62
SCOY7	"		.70		.70		.70		.70		.70
SYAM6	100	76.29		76.29		63.45		256.29		76.29	
SYAM7	Lb	70.93		70.93		58.98		238.33		70.93	
SVEG4			.05		.05		.05		.05		.05

Table B.4b Continued.

Resource	Unit	Level	Π	Level	Π	Level	Π	Level	Π	Level	Π
		2A		2B		2C		2D		3A	
TVEG4	Lbs	5.57	Cedis	5.57	Cedis	5.57	Cedis	5.57	Cedis	5.57	Cedis
SVEG5	"		.045		.045		.047		.046		.045
TVEG5	"		.009		.009		.011		.010		.009
SVEG6	"		.030		.030		.030		.030		.030
TVEG6	"		.013		.013		.013		.013		.013
SVEG7	"		.020		.020		.020		.020		.020
CROPPING: 1 MZM	Acre		454.58		477.80	21.43		454.26			454.58
2 MCV	"		259.05		273.21		260.02				259.35
3 MCY	"	8.48		8.48		7.05		28.48		8.48	
4 MCPY	"		276.38		282.76		280.57		20.55		192.31
5 MCPOV	"				287.90				115.00		217.82
6 MCO	"		23233.08		25006.43		22540.45		23060.61		23731.60
7 MZN	"	4.0		4.0		14.0		14.0			5.31
8 MZA2	"										437.56
9 MZA3	"										654.52
10 CASA1	"										270.64
11 CASA2	"										272.29
12 PLATA1	"										0
13 PLATA2	"										0
14 COYOA1	"										86.34
15 COYOA2	"										88.02
16 YAMA1	"										171.11
17 YAMA2	"										174.04
18 VEGA1	"										134.88
19 VEGA2											145.32
20 MZNA1	"									4.0	
21 MZNA2	"										1.32

Source: Computed

Π : Shadow Prices

APPENDIX C

Table C.1. Alternative Resource Expansion Category I Farms, Phase II, All Regions.

GROSS INCOME AND AVERAGE MEASURES	UNITS	R E G I O N									
		BRONG-AHAFO		ASHANTI		EASTERN		CENTRAL		VOLTA	
		2A	2B	2A	2B	2A	2B	2A	2B	2A	2B
Gross Income	Cedis	4175.84	4304.91	3012.4	3173.33	2903.16	3012.4	3327.7	3463.07	3339.64	3793.16
Total Acres	Acre	14.73	14.73	10.38	10.7	10.32	10.38	11.58	11.55	10.74	10.75
Amount of Hired Labor	Hours	50.87	3366	3722	2457	3246	2143	3945	2604	3902	2110
Amount Borrowed	Cedis	449.53	374.6	474.3	542.8	549.7	474	427.57	352.16	607.33	434.92
Return Per Acre	Cedis	283.49	292.25	290.2	296.57	281.3	290.2	287.37	299.06	310.66	344.48
MVP of Land (Major)		398.7	424.2	362.76	397.7	401.06	435.0	376.6	418.8	449.6	526.0
Return Per Man Hour	Cedis	.40	.5	.41	.52	.46	.5	.38	.47	.46	.67
Return Per Capital	Cedis	7.26	8.6	5.63	4.48	4.76	5.63	6.26	7.6	5.26	8.02
Labor Hours Per Acre	Hours	705.0	588	712	572	665.0	555.	749	633	679.0	512
Amount Borrowed per/ Acre	Cedis	30.52	25.43	45.69	50.73	53.27	45.69	36.92	30.41	56.5	40.46
Ratio of Hired Labor to Total Labor Input		48.98	38.84	50.3	40.13	47.28	37.19	45.5	35.53	53.47	38.33
Cropping Maize-Cassava Plantain-Cocoyam-Yam	AC	9.6	9.6							6.98	
Maize-Cassava-Cocoyam-Yam-Pepper	Acre										
Maize-Cassava-Plantain-Cocoyam-Yam						6.3	6.3				

Source: Computed

APPENDIX D

Table D.1. Population Census 1970: Brong-Ahafo Region (In Numbers).

Locality	Sex	Ages (In Years)									Total Aged 15 & Over	Economic Activity				
		All Ages	Below 1 Year	1-4	5-9	10-14	15-24	25-44	45-64	65 & Over		Employed		Unemployed	Home Maker	Other
												Total	In Agri. Hunting, Forestry & Fishing			
Badu (Wenchi District)	M	1938	89	278	297	246	344	382	184	118	1028	816	632	29	3	180
	F	2087	71	275	379	238	344	453	210	117	1124	888	747	5	145	86
Techiman	M	5948	264	974	904	670	1032	1525	426	153	3136	2603	1212	154	10	369
	F	6120	254	960	1036	745	1167	1402	403	153	3125	2317	1020	69	471	268
Total																
Mmim (Goaso District)	M	5001	195	705	701	538	1026	1373	343	120	2862	2300	1296	142	14	406
	F	4629	195	752	765	618	861	983	305	150	2299	1345	754	24	688	242
Watro (Atebubu District)	M	57	3	8	8	10	7	12	6	3	28	24	22	---	---	4
	F	88	1	12	16	9	11	16	14	9	50	39	37	1	---	10
Rest of Enumeration Areas	M	642	17	70	86	45	122	212	72	18	424	394	388	3	2	25
	F	382	20	59	80	32	74	96	20	1	191	155	152	1	29	6

Source: Ghana Census of Population 1970. Central Bureau of Statistics, Accra.

Table D.2. Population Census 1970: Ashanti Region (In Numbers).

Locality	Sex	Ages (In Years)									Total Aged 15 & Over	Economic Activity				
		All Ages	Below 1 Year	1-4	5-9	10-14	15-24	25-44	45-64	65 & Over		Employed		Unemployed	Home Maker	Other
												Total	In Agri. Hunting Forestry & Fishing			
Krobo	M	263	5	46	47	36	39	59	22	9	129	101	66	9	---	19
	F	259	6	43	48	29	37	60	27	9	133	106	101	1	6	20
Rest of Enumeration Areas	M	117	4	14	21	25	17	22	6	8	53	41	28	4	1	7
	F	106	1	19	21	12	15	21	12	5	53	40	35	2	6	5
Ejura	M	5439	202	820	828	493	774	1706	519	97	3096	2656	1697	231	12	197
(Adwira)	F	5225	198	891	878	517	923	1452	285	81	2741	1646	363	85	845	165

Source: Ghana Census of Population, 1970. Central Bureau of Statistics, Accra.

Table D.3. Population Census 1970: Volta Region (In Numbers).

Locality	Sex	Ages (In Years)									Total Aged 15 & Over	Economic Activity				
		All Ages	Below 1 Year	1-4	5-9	10-14	15-24	25-44	45-64	65 & Over		Employed		Unemployed	Home Maker	Other
												Total	In Agri. Hunting Forestry & Fishing			
Kpandu	M	6694	163	736	824	799	2031	1387	580	174	4172	2325	576	174	10	1663
	F	6184	176	763	929	812	1281	1395	551	241	3468	2275	361	114	556	523

Source: Ghana Census of Population, 1970. Central Bureau of Statistics, Accra.

Table D.4. Population Census 1970: Eastern Region, Sekesua (In Numbers).

Locality	Sex	Ages (In Years)									Total Aged 15 & Over	Economic Activity				
		All Ages	Below 1 Year	1-4	5-9	10-14	15-24	25-44	45-64	65 & Over		Employed		Unemployed	Home Maker	Other
												Total	In Agri. Hunting Forestry & Fishing			
Sekesua	M	613	17	84	93	66	90	163	67	33	353	298	156	6	26	49
	F	539	15	77	81	68	91	116	60	31	298	233	80	5	--	34
Sekesua-Agbletsom	M	127	4	23	19	16	20	28	13	4	65	49	45	1	3	15
	F	117	4	13	20	16	11	25	18	10	64	54	37	1	--	6
Rest of Enumeration Areas	M	95	3	9	11	17	17	21	9	8	55	42	30	3	5	10
	F	88	4	15	15	10	16	17	10	1	44	28	8	--	--	11

Source: Ghana Census of Population, 1970. Central Bureau of Statistics, Accra.

Table D.5. Population Census 1970: Central Region, Gomoa Akwamu (In Numbers).

Locality	Sex	Ages (In Years)									Total Aged 15 & Over	Economic Activity				
		All Ages	Below 1 Year	1-4	5-9	10-14	15-24	25-44	45-64	65 & Over		Employed		Unemployed	Home Maker	Other
												Total	In Agri. Hunting Forestry & Fishing			
Akwamu	M	313	2	54	55	45	59	49	34	15	157	110	94	6	1	40
	F	354	6	53	49	54	52	86	44	10	192	175	163	--	3	14
Rest of	M	119	7	29	20	13	18	15	12	5	50	35	31	2	3	13
East Africa	F	113	4	24	16	11	10	33	15	--	58	54	51	--	3	1
Gomoa--	M	665	27	95	119	80	112	132	53	47	344	298	246	6	2	38
Lome	F	754	27	112	122	76	135	165	66	51	417	362	334	--	25	30

Source: Ghana Census of Population, 1970. Central Bureau of Statistics, Accra.

APPENDIX E

Table E.1. Marginal Value Products and Prices of Seasonal Product Inventories (By Region).

	Eastern		Volta		Central		Brong-Ahafo		Ashanti	
	MVP	Price	MVP	Price	MVP	Price	MVP	Price	MVP	Price
MZOP1	12.83	12.2	13.82	12.2	12.93	12.2	10.6	10.0	10.55	9.94
MZOP2	15.19	14.45	15.72	14.4	15.19	14.5	13.4	12.75	14.0	13.33
MZOP3	12.79	12.26	14.46	12.25	12.79	12.26	9.6	9.25	10.77	10.33
MZOP4	8.39	8.39	11.66	8.40	13.37	8.39	8.14	5.4	10.8	6.22
MZOP5	14.3	9.24	14.98	9.70	13.74	9.24	8.37	5.04	11.18	5.61
MZOP6	14.7	11.32	13.11	12.2	14.12	11.32	8.6	6.4	11.86	8.71
MZOP7	14.8	14.8	14.0	4.8	14.28	14.28	8.73	8.73	12.7	12.7
PLAOP1	.46	.44	.65	.52	.46	.44	.75	.71	.45	.42
PLAOP2	.47	.45	.62	.55	.47	.45	.69	.66	.45	.43
PLAOP3	.71	.68	.79	.69	.71	.68	.74	.71	.71	.68
PLAOP4	.95	.95	1.06	1.0	.97	.95	.81	.78	.77	.77
PLAOP5	1.01	1.0	1.01	.96	1.03	1.0	.87	.85	.55	.55
PLAOP6	.75	.75	.98	.89	.76	.75	.62	.62	.47	.47
PLAOP7	.48	.56	.45	.45	.56	.42	.58	.52	.32	.32
CASOP1	4.47	4.25	6.14	5.2	4.5	4.25	3.4	3.25	3.39	3.2
CASOP2	3.47	3.3	5.42	4.6	3.47	3.3	3.5	3.37	3.79	3.6
CASOP3	4.55	4.36	6.3	5.1	4.55	4.36	3.7	3.6	3.93	3.77
CASOP4	4.38	4.38	5.3	4.4	4.5	4.38	3.6	3.5	2.5	2.5
CASOP5	3.52	3.52	5.9	5.1	3.6	3.52	3.8	3.75	2.0	2.0
CASOP6	3.85	3.85	5.5	5.2	3.9	3.85	4.0	3.8	2.2	2.22
CASOP7	3.64	3.66	5.7	5.7	3.64	3.64	3.9	3.51	2.1	2.1
COYOP1	9.64	9.17	5.6	4.6	9.72	9.17	9.49	8.96	7.95	.75
COYOP2	4.1	3.9	5.26	4.1	4.1	3.9	9.28	8.83	10.51	10.0
COYOP3	6.15	5.9	6.23	5.3	6.15	5.9	11.8	11.32	10.42	10.0
COYOP4	6.5	6.5	6.58	5.4	6.67	6.5	11.3	11.0	9.83	9.83
COYOP5	6.4	6.4	6.88	5.6	6.56	6.4	8.46	8.25	10.33	10.33
COYOP6	5.81	4.2	6.03	5.9	8.13	4.0	6.68	6.68	6.9	6.9
COYOP7	6.25	6.95	6.46	6.46	6.95	6.25	6.2	5.58	6.33	6.33
YAMOP1	44.46	42.29	36.7	32.4	44.83	42.29	32.06	30.25	34.87	32.69
YAMOP2	51.2	48.7	39.4	34.2	51.2	48.7	38.63	36.75	34.69	33
YAMOP3	58.4	56.0	46.2	41.3	58.4	56	30.7	29.49	36.49	35
YAMOP4	37.75	37.75	37.11	33.2	38.72	37.75	25.85	25	15.3	15.33
YAMOP5	39.75	39.0	34.66	33.1	40.0	39.0	21.79	21.25	17.0	17.0
YAMOP6	42.0	35.0	38.59	38.4	42.0	35.0	28.87	18.34	27.16	21.7
YAMOP7	45.0	45.21	41.5	40.6	45.2	45.21	31.0	31.0	29.2	29.2
VEGOP1	.14	.13	.13	.09	.14	.13	.13	.13	.13	.13
VEGOP2	.12	.12	.12	.11	.13	.12	.12	.12	.12	.12
VEGOP3	.11	.11	.11	.09	.15	.11	.11	.11	.11	.11
VEGOP4	.15	.10	.12	.12	.15	.10	.106	.09	.14	.09
VEGOP5	.15	.11	.12	.11	.16	.15	.12	.09	.14	.10
VEGOP6	.16	.13	.13	.11	.16	.11	.12	.12	.15	.12
VEGOP7	.16	.14	.14	.09	.16	.15	.129	.126	.14	.14

Source: Computed.

APPENDIX F

APPENDIX F

The APPEX-1 Reference Manual supplied by the Control Data Corporation (CDC) to be used on CDC 6500 computer and the Harsh-Black control program were the primary source for deriving the linear programming solutions for this study. Basically, the APEX-1 is an optimization system, its main function being to optimize MPS formatted linear models to either maximize gains or minimize losses. In this study, the data generated by the Harsh-Black optimization system were using an appropriate subroutine, transformed into a linear model that the APEX-1 system could analyze.

The following files, representing the matrices for the representative farms in the three phases of analysis, are contained on Tape 64, APLIB or Applications Programming Library, Computer Center, Michigan State University, East Lansing, Michigan.

Appendix F (Continued)

Library File Name (LFN)	Position
R3F2M08	Random 01
R1F2M8	" 02
R5F1M9	" 03
R1F2D8	" 04
R4F2M08 (Abandoned)	" 05
R1F2J1	" 06
R3F1R1	" 07
R2F1R1	" 08
R3F2J1	" 09
R4F2J1	" 10
R1F1J1	" 11
R4F1R1	" 12
R5F1J1	" 13
R5F2J1	" 14
R5F2M1	" 15
R5F1M1	" 16
R2F1M1	" 17
R4F1M1	" 18
R1F1M1	" 19
R1F2M1	" 20
R2F1J1	" 21
R3F2M1	" 22
R3F1J1	" 23
R4F1J1	" 24
R4F2M1	" 25
R1F1D2	" 26
R5F2G2	" 27
R5F2M8	" 28
R3F2M8	" 29
R4F2M8	" 30
R5F1M8	" 31
R1F2M08	" 32

Where R1. . .R5 represent region 1. . .region 5 and F1 and F2 represent Category I and Category II farms, respectively.

To obtain files off the tape will require the following control cards and procedures:

Appendix F (Continued)

I. Obtaining Files Off the Tape and Range Report

```
PNC (or program name card)
JØB Card
PW or Password
ATTACH, APLIB, APLIB.
APLIB, TT64, R*(Insert LFN here)  = OLDPL.
UPDATE, C = Tape 1,N.
CATALOG, NEWPL, (PFN), ID = ATTA.
HAL, CONTRØL, O = ØUTPUT, CC = 9.
HAL, *APEXI.
AUTORFL, PART.
RFL, 42000.
APEX, SOLVE, MAX, RANGE, L, TER = 300, LOG = 50.
6
 7
  8
   9
```

II. Obtaining Listing of Matrix and Linear Equations and Range Report

```
PNC
JØB Card
PW
DMPX (OFF)
ATTACH, ØLDPL, (PFN).
UPDATE, C = TAPE 1, F.
LISTTY, I = TAPE 1, W95.
HAL, CØNTRØL, O = ØUTPUT, CC = 9.
HAL, *APEXI.
AUTØRFL, PART.
RFL, 42000.
APEX, SØLVE, MAX, EQ, RANGE, L, TER = 300, LØG = 500.
6
 7
  8
   9
```

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