1986

Decision making behavior of small scale farming households: the case of Zambia

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Decision making behavior of small scale farming households: The case of Zambia

by

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A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Iowa State University
Ames, Iowa

1986

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CHAPTER 1. INTRODUCTION

Problem Situation

The agricultural sector is a major contributor to the Gross Domestic Product. It forms a major source of domestic food supply, supply of raw materials to agro-industries, and a source of employment opportunities for the rural population.

The current performance of the agricultural sector is strikingly low. Between 1978-82, agricultural growth registered a disappointing 1.9 percent (World Development Report, 1984) against a population growth rate of 3.1 percent. The 1980 population census report estimates that the population is likely to double in the next two decades (GRZ:NCDP, 1981a). Against this background, it is necessary that government not only adopt policies designed to slow population growth but simultaneously increase the level of agricultural output to meet domestic food demand and achieve significant economic growth. Although value added in agriculture rose from US $278 in 1978 to US $325 in 1982 (millions of 1975 dollars), the shortfall in food production has led to a significant increase in food imports. Cereal imports rose from 93,000 tons in 1974 to 225,000 tons in 1982 (Wood, 1984). Food aid in cereals also rose from 1,000 tons during the 1974-75 season to 100,000 tons during the 1981-82 season. Similarly, food prices have risen significantly in the recent past. Agro-industries continue to operate at less than full capacity (World Bank, 1985). Various reasons have been advanced for the agricultural sector's poor performance. Probably the most often mentioned has been low producer prices.

The national seminar on agricultural planning in Zambia points out that returns to management are too low (GRZ:MAWD and NCDP, 1984). This group also highlights the need to investigate the impact of uniform pricing on the national objective of food self-sufficiency, as well as the sensitivity of the pricing process to consumer interests. Results from a study on producer prices using the "cost of production approach" based on the assumption that the relative profitability of agricultural products determines farm-household crop choices showed that, based on 1978 producer prices, farmers would respond by producing a mix of crops in the following ranking: Virginia tobacco, seed cotton, groundnuts, sunflowers, and maize. The parity between agricultural products and nonagricultural products favored the latter. Although these results are not wholly satisfactory due to methodological pitfalls, the above exposition reveals that not only are the terms of trade biased against agriculture but that crop ranking favors commercial-industrial crops against food crops. Therefore, there is need to balance agro-industry and export needs with domestic food production and food security. Food security objectives (i.e., the ability to meet minimum domestic food requirements with certainty) require a significant reduction in dependence on food imports even with adequate foreign exchange earnings owing to inherent supply and price fluctuations in the international food markets and imperfect market information flows.

An insufficient resource base has been sighted as a factor responsible for the agricultural sector's poor performance. An assessment of resource adequacy requires an evaluation of the overall agricultural

sector financing requirements. Evidence suggests that dependence on government and foreign funding in the agricultural sector has grown in recent years with an absolute increase in the sector's share of the national budgetary outlay. Foreign assistance to Zambia, for instance, rose from US $20 million in 1970 to US $389 million in 1982, an annual growth rate of 33.1 percent (Wood, 1984). Technical assistance to the agricultural sector also rose from 14 percent of the total aid received by Zambia in 1975 to 33 percent in 1977. Furthermore, capital aid rose from less than ten percent in 1977 to 25 percent in 1982. Against this background, it is necessary to evaluate the nation's and farmers' self-financing capacity. A government study estimated that there has been a substantial amount of internal financing giving a national internal financing ratio of 43 percent.[1] Furthermore, based on a sample of 86 households in the Eastern province, a 77 percent internal financing ratio was estimated (GRZ:MAWD, 1983a). Although these results are not definitive due to data inadequacies, they highlight the need to analyze financing requirements of the sector relative to the technology available and the level of farm operations.

Smallness of farms and low levels of technology are other factors responsible for the agricultural sector's poor performance. From a national perspective, the interest in farm size is embedded in the need to ensure optimum efficiency in the use of resources for food production and other competing activities. From the point of view of farming

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[1] Internal financing ratio refers to the ratio of equity capital to total farm operating expenses.

households, optimum efficiency is required in order to achieve increased food self-sufficiency, increased levels of income, and higher levels of nutrition (Ball and Heady, 1972). It should be pointed out, however, that farm size is a static concept whereas growth emphasizes the question of increment in size over time.

The low levels of technology have led to low levels of productivity and low income earnings. Subsistence agriculture is a special stage of equilibrium, departure from which requires the application of "new" inputs, means of production, and knowledge about the production of new outputs (Ruthenberg, 1976; Schultz, 1964). Components of technical change include new materials, "new implements" and power source, and new cultural practices. These technological changes have been categorized into those that increase the level of output per unit of land, i.e., the intensive margin, and those that lead to expanded acreage cultivation, i.e., the extensive margin. Both lead to increased levels of output and incomes.

The need to increase food supply and achieve food self-sufficiency, food security, and increased levels of agricultural production have formed a central theme in the past and current development plans. It is clear that in persuancy of these goals, government plays a very significant role by directly and/or indirectly affecting agricultural sector performance through various instruments and mechanisms. The government defines the direction and pace of development of the farming households and the sector through its pricing policies, budgetary allocations, credit policies, pattern of international alliances,

monetary and fiscal policies, etc. Farming households respond to those policy objectives by adjusting their production, resource supply, and consumption decisions so as to maximize net benefits. It is hoped that through a careful application of analytical tools one could attempt to understand the decision making behavior of farming households and seek to minimize the potential conflict between the objectives of policy makers and the aspirations of farming households.

In order to achieve these goals, it is necessary that a reliable data base be in place because agricultural development and increased production levels rely both on creating effective investment opportunities and efficient utilization of existing resources. Similarly, it is important that reasonable information be available on the physical resources, levels of farm income, net revenue of different enterprises, and the potential increase in income and production which could result from a rational utilization of existing and newly created resources. Furthermore, the problem of inadequate agricultural supply requires an understanding of the factors which influence resource demand and product supply of individual farm firms. Therefore, there is need to understand the decision making behavior of farming households as to the sources and uses of resources and the pattern and direction of change owing to changes in key policy variables.

One necessary condition is for planners and decision makers to obtain adequate information so that the consequences of policies formulated can adequately be anticipated. In the past, the lack of adequate information and the inability to comprehend both internal and

external forces have led to large gaps between government intended objectives (target levels) and achievement levels. Therefore, without a clear understanding of the farm structure, the pattern of price response and the economic organization and motivations of farming households, planners and policy makers cannot fully evaluate the potential impact of agricultural programs on the volume of production, farm incomes, consumption, nutrition, and the general welfare of society.

Assuming the foregone discussions are reasonably true, what policy combinations and/or by how much should producer prices be increased, production costs reduced, and consumer prices maintained in order to generate adequate income levels within existing technology and/or improved technology? Another related question is, at what level of operation can a combination of policies and producer and input prices enable the farming household to earn a reasonable level of income without significantly raising the prices of food to consumers, lowering the nutritional levels, and raising the prices of raw materials to industry.

This study seeks to make a contribution towards the knowledge and information necessary for the formulation of rational policy packages consistent with meeting micro and macro level objectives.

The Objectives of Study

1. Review current practices to determine what farmers are doing (positive phase) and hypothesis testing which seeks to explain and rationalize the behavior of farming households.

2. Develop a one-period linear programming model for an average farming household practicing mono cropping under handhoe and oxen technologies.
3. Identify and analyze of production potential, levels and patterns of resource use, consumption behavior, and nutritional levels, i.e., normative phase which seeks to determine what farming households ought to be doing to achieve stated objectives.
4. Through parametric programming analyze the impact of varying levels of capital availability on resource and consumption patterns.
5. Analyze results and form generalizations by carefully identifying those factors which significantly influence the decision making behavior of farming households. This is the policy phase which attempts to narrow the gap between policy objectives 3 and 4 above.

CHAPTER 2. STRUCTURE OF AGRICULTURAL PRODUCTION IN THE STUDY AREA

Data Sources

The study area

The data forming the basis for this chapter are based on a household survey of 42 households in the Central province of Zambia during the fall of 1982. The survey was part of a larger survey carried out in two other provinces, Southern and Northern provinces. It was primarily designed to examine women's contributions to household incomes, participation in market activities, and resource inputs into farming systems (Due and Mudenda, 1985). Much of the input-output data was based largely on this survey supplemented by information from government publications and personal interviews with farming households in the countryside.

The study area (Mubwa District) is located approximately 50 kms northwest of Lusaka. The area is characterized by two distinct seasons, the dry and west seasons. The wet season begins in November and lasts until April. The area is agricultural in nature and because of its proximity to a large population center linked by an all weather road, it is one of the most productive agricultural areas. In general, farming practices involve large commercial farming activities and of interest in this study are small farming households with limited resource bases, using handhoe technology and oxen technology. Fertilizers, chemicals, and improved seed are used where capital is available and households perception of the level expected incomes.

Resource Utilization and Production Practice

Family labor force

The family provides the bulk of the farm labor force, with supply supplemented occasionally by relatives and friends. Labor hiring activities are limited to specialized operations, for example, stumping and/or oxen cultivation. During the farming season, females contribute an average of 53 percent of total household labor supply to agriculture while males contribute 47 percent. There is a strong correlation between farm size, the level of agricultural commercialization, level of input use, and level of labor hiring activities by farming households (Due and Mudenda, 1985).

The intensity of work by the family shows a seasonal pattern. Other studies have shown that during the peak labor months, the number of hours spent resting per day significantly declines (Crawford, 1982; Elliott, 1970), reflected in man-days available for farming activities per month. The proportion of time devoted to resting fell from a peak of 27 percent (i.e., over three hours in a 12-hour working day) to less than 16 percent at harvest time. Similarly, resting for male adult visitors feel from 78 percent in November to 30 percent in February (i.e., during the weeding period) while the percent of time spent on crop production activities rose from five percent in November to 16 percent in January. The wage rates received by rural wage earners depend on the task to be performed. The government regulated minimum wage rate is about K2.00 per day. Payments are also effected through barter transactions.

Table 2.1. Average farming household and oxen labor supply and demand by crop and by season per acre[a,b]

	August-November			December-May			June-July		
	I	II		I	II		I	II	
	MD	MD	OD	MD	MD	OD	MD	MD	OD
Maize	17.14	6.76	4.85	33.20	19.53	2.44	18.42	18.62	1.29
Beans	-	3.05	3.24	108.00	21.19	0.65	-	-	-
Groundnuts	31.17	19.93	3.44	70.85	44.47	1.62	75.71	38.06	0.17
Cotton	32.79	5.23	1.21	72.04	39.55	2.43	30.36	21.80	0.24
Sunflowers	-	3.62	2.43	84.21	17.75	0.63	44.94	9.72	0.37
Total	81.10	38.59	15.17	368.30	122.96	7.77	169.43	88.20	2.07
Total family labor supply	452.18			1137.78			308.71		

[a]I = handhoe technology, II = oxen technology, MD = man-days, OD = oxen-days.

[b]Source: Compiled by author from (Elliott, 1970; GRZ:MAWD, 1982).

Sources of cash income

Marketing of farm crop products forms a significant source of household income accounting for 75 percent of gross income while livestock sales accounted for 25 percent of gross farm income (Table 2.2). Other sources of income include off-farm employment, petty trade, and gifts received from friends and relatives. Table 2.3 shows that 41 percent of total off-farm income was earned from off-farm employment, 44 percent from petty trade, and 15 percent from gifts.

Table 2.2. Average farm income from crop and livestock sales[a]

Item	Amount (K)
On-farm:	
Crop sales	373.00
Livestock sales	114.00
Subtotal	487.00
Less:	
Farm expenses	214.00
Net farm income	273.00
Returns per acre (crops)	28.14

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

Table 2.3. Average off-farm income by source[a]

Source	Amount (K)	Share
Employment	73.00	0.41
Petty trade	78.00	0.44
Gifts	26.00	0.15
Other	1.00	0.01
Total	178.00	1.00

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

Uses of capital

Farm capital There are two main sources of farm capital, owner savings and borrowed capital. Family equity is a very small proportion of total farm capital. The predominance of subsistence farming and consequent low farm incomes due to smallness of farms and low yields militate against capital accumulations.

Capital borrowing The principal sources of credit for farm inputs are the Agricultural Finance Company (AFC) and the Lint Board. The Lint Board provides inputs, extension services, and marketing outlets for cotton and soybeans. Credit needs for all other crops must be met from AFC, friends and relatives, and the Cooperative Credit Unions (CCU). Out of the total sample surveyed, 44 percent reported borrowing and about 28 percent of those borrowing obtained credit from the Lint Board, 22 percent from friends and relatives, and, finally, 11 percent obtained credit from Cooperative Credit Unions (Table 2.4).

Table 2.4. Average amounts and sources of credit in the study area[a]

	No. of families	Amount
Average borrowed--all families (K)		225
Average borrowed per family borrowing (K)		747
Sources:		
AFC	5	
Lint Board	7	
Friends and relatives	4	
Cooperative Credit Unions	2	
Total	18	

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

The average level of borrowing was K747.00, while the most frequent amount borrowed was less than or equal to K100.00. The level of borrowing seems to be strongly associated with the degree of agricultural

commercialization and farm size. Credit use shows that 49 percent of credit recipients used it on fertilizer and/or hybrid seed, 20 percent obtained insecticides, four percent used credit to purchase cattle, six percent used credit on unspecified farm inputs, while two percent used credit for purposes other than what it was intended for. In order for the credit program to be successful, credit recipients must honor their credit obligations. Evidence from the survey shows a 66 percent repayment rate while of the total number of families borrowing, 88 percent are reported to honor their credit obligations (Table 2.5).

Table 2.5. Mean amount borrowed and repaid[a]

Number borrowing	18
Percentage of families borrowing	43
Amount borrowed (K)	525
Amount repaid (K)	347

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

Farm operating expenses Fertilizer expenses were the largest accounting for 48 percent of total operating expenses as shown in Table 2.6, seed accounted for 20 percent, labor hiring accounted for 14 percent, while chemicals, farm tools, and others accounted for 18 percent of total farm expenses. Land rent and oxen expenses only accounted for eight percent of the total farm expenses.

Table 2.6. Average farm operating expenses[a]

Item	Average expenditures (K)	Average share
Labor	30.00	0.14
Seed	43.00	0.20
Fertilizer	103.00	0.48
Farm tools and supplies, transport, etc.	38.00	0.18
Total	214.00	1.00

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

Consumption Profile of the Average Farming Household

Family living expenses

Farming households on average spent K403.00 on a variety of family expenses per year. Table 2.7 shows that food, clothing, and footwear each accounted for 27 percent of the average expenditure, followed by expenses on services accounting for 25 percent of average expenditures.

An investigation of the overall household income use taking into account imputed value of on-farm consumption shows that household expenses account for 64 percent of total value of expenditures with food accounting for 46 percent. Farm expenses and household investment each accounted for 22 percent and 14 percent, respectively. After accounting for all expenses, it is estimated that savings is approximately K18.00 per annum.

Table 2.7. Mean expenditures by commodity groups[a]

	Average household expenditure	Average share
A. Household expenses		
1. Food		
(i) On-farm	335.00[b]	
(ii) Purchased foods	110.00	0.18
2. Nonfood expenses	44.00	0.07
3. Services expenses	100.00	0.16
4. Transfer and gifts	12.00	0.02
B. Household investment		
1. Clothing and footwear	109.00	0.18
2. Household goods	28.00	0.05
C. Farm investments		
1. Farm tools	3.00	--
D. Operational expenses	211.00	0.34
Total	617.00[c]	1.00

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

[b]Imputed value of on-farm consumption (crops).

[c]The total excludes imputed value of on-farm consumption.

Kinds of Crops and Cropping Pattern

Climatic conditions are favorable to the production of a variety of crops. Several crops are cultivated in the study area, for instance, millets, sorghum, wheat, potatoes, vegetables, and other garden crops. Information relating to their value relative to household consumption needs and income generating capability and their demand on household resources is not available. Also, livestock activities are reported but necessary data are not available to incorporate them in the model. Available data and information shows that farming households practice

mono cropping. Although mixed cropping practices are not reported, they are widely practiced. Mixed cropping is a risk management strategy widely recognized as central to the survival of peasant farming households. The disadvantages of mixed cropping could be stated as follows:

(i) mixed cropping can lead to reduced yields due to crop competition for nutrients, space, and light;

(ii) lower plant density of individuals crops; and

(iii) limit the adoption of improved technology, e.g., oxenization of certain field operations.

The advantages include:

(i) higher total population density leading to higher yields per acre, and

(ii) minimization of risk arising from crop failure due to weather uncertainties.

Based on the above discussion, it is necessary that mixed cropping recommendations be based on sound and well-tested scientific research relative to existing technologies.

Land allocation decisions show that maize is the dominant crop reflecting current government policy (Table 2.8). Cotton is the second most important crop. However, its significance seems to be enhanced by the Lint Board's provision of credit, extension services, and marketing outlets. This is so because even without allowing it to compete for resources with other crops, its profitability (K1.80/man-day) was shown to be lower than sunflowers (K2.40/man-day) and/or beans (K2.80/man-day). Furthermore, cotton is a very labor intensive crop.

Even for medium-scale commercial farmers, one hectare is considered to be too large (GRZ:MAWD, 1981b). Also, and perhaps most important, is the fact that farming households attempt to save on all cash inputs, hence spending less on insect control, an essential cash input, consequently resulting in low yields. Groundnuts are equally very labor intensive while their profitability is significantly reduced by low producer prices (GRZ:MAWD, 1983b).

Table 2.8. Land allocation of specific crops (acres)[a]

Crop	Total	Average	Average share
Maize	252.00	6.00	0.61
Beans	2.00	0.20	0.02
Groundnuts	20.80	0.80	0.08
Cotton	20.40	1.70	0.17
Sunflowers	14.00	1.00	0.10
Other	1.00	0.10	0.01
Total	310.00	9.80	1.00

[a]Source: Compiled by author from survey report (Due and Mudenda, 1985).

Farm objectives

Although profit maximization behavior is appropriate, it has been observed that a combination of security and profit maximization closely reflects the behavior of farming households. Food self-sufficiency and income generation are both seen to contribute towards food security.

Table 2.9 shows that not only are some crops grown purely for subsistence but that a significant portion of other crops is retained for home consumption. Evidence shows that 54 percent, 57 percent and 10 percent of maize, groundnuts and sunflower is retained for consumption, respectively. It is not clear, however, if these levels of consumption meet the minimum recommended nutritional levels. The nutritional requirements were calculated using information from the Food Composition Tables for Zambia (GRZ:NFNC, 1971).

In order to convert the coefficients into minimum annual family nutritional requirements, the average family unit was standardized into annual consumption equivalent units. Given the nutritional requirement per adult consumer equivalent and average family size, the annual minimum nutritional requirements were estimated for the relevant nutrients (Table 2.10).

Table 2.9. Production, consumption, and marketing of major crops[a]

	Production		Marketed		Average share	Consumption		Average share
	Total kg	Average kg	Total kg	Average kg		Total kg	Average kg	
Maize	98,952.00	2,356.00	45,780.00	1,090.00	0.46	53,172.00	1,266.00	0.54
Beans	310.00	31.00	-	-	-	310.00	31.00	1.00
Groundnuts	4,368.00	168.00	1,924.00	72.00	0.43	2,496.00	96.00	0.57
Cotton	2,664.00	222.00	2,664.00	222.00	1.00	-	-	-
Sunflowers	1,092.00	78.00	980.00	70.00	0.90	112.00	8.00	0.10
Other	630.00	63.00	-	-	-	630.00	63.00	1.00

[a]Source: Compiled by author from survey reports (Due and Mudenda, 1985).

Table 2.10. Annualized nutrition supply and requirements per kg by source for the average household in standard units[a]

	Maize	Beans	Groundnuts	Minimum annual requirements
Calories	14,520.00	13,560.00	23,160.00	28,651,537.43
Protein	300.00	960.00	1,080.00	734,325.09

[a]Source: Compiled by author from (GRZ:NFNC, 1971).

CHAPTER 3. REVIEW OF THEORETICAL AND EMPIRICAL STUDIES

Farming Household Linear Programming Models

The application of linear programming to studying farming households recognizes that the farming household is a combination of two units of microeconomic activity--household and farm. The approach is capable of showing the interdependency among enterprises with respect to changes in resource availability and levels of use and changes in relative price ratios of different products and factors. Subsistence agriculture shows overwhelming dependence of the household upon the output of the farm for its consumption requirements for food and other outputs and by the overwhelming dependence of the farm upon the household for its labor requirements (Tesfaye, 1984).

The resulting implications are such that production and consumption decisions should be analyzed jointly. Household consumption requirements may have an influence on a farm's cropping pattern if food crops compete with nonfood cash crops for land and other resources. Consumption needs often lead to diverse cropping patterns since a variety of nutritional needs have to be met. Therefore, economies arising from specialization are lost. Consumption requirements also influence the level of commercialization of production and, hence, the amount and composition of marketable surplus. Marketable surplus is a major source of cash incomes and the means by which farm inputs are obtained.

Consumption and on-farm investments are intertwined. Significant input into subsistence agriculture is provided by the household; the

amount of family labor available on the farm depends upon the choice between leisure and income. Some authors have suggested that subsistence farmers are "target" farmers (Lewis, 1966). This means that farmers produce for the market so far as to meet specific consumer demand which if met removes the incentive to produce further for the market beyond the immediate cash and/or consumer demand. This phenomenon may not be a reflection of low aspirations but rather unwillingness to work for extremely low marginal returns (Singh, 1971). Furthermore, it should be pointed out that investments that significantly raise labor productivity decrease the relative importance of leisure and increase the supply of family labor.

On-farm investments are limited by the household's ability to save, since in subsistence agriculture a significant portion of capital accumulation is done either through a direct expenditure of labor on farm improvements or through savings. Rates of savings and investment may be low because of low rates of returns expected from investments in farm inputs or because of high rates of discount for future incomes arising from uncertainty and risk in traditional agriculture. Preferences for low mean incomes but less variable over high incomes is consistent with rational behavior given the inability of farming households to control the physical environment on which subsistence agriculture depends.

Savings may be low at low levels of output after subsistence consumption needs have been met. At the micro level, the ability to invest is very much determined by the surplus of production over

consumption for a given household. Therefore, at very low levels of consumption, consumption and investment cannot entirely be separated even as concepts since food requirements are essential for maintaining the primary production input-family labor, and can be considered as investment in a very durable and versatile asset. Against this background, the decisions to consume, produce, and invest cannot be separated except as useful descriptions of various types of activities observed in the farm household.

Amount and composition of marketable surplus depends upon both decisions to retain outputs for consumption as well as decisions to produce those outputs. Marketable surplus determines the cash flow position of the farming household and subsequently the extent to which the household invests in variable and quasi-fixed nonfixed inputs. Therefore, an increase in the cash flow ceteris paribus becomes a necessary condition for investment in new technology, current production which enables the household to purchase inputs, and, finally, the transformation of subsistence agriculture. Against this background, the need for credit institutions, availability and terms of credit, and sources and uses of credit cannot be overemphasized.

On-farm investments and consumer demand compete for limited resources available to the household. The household participates in the market place to dispose farm outputs and acquire consumer goods, hence as the farming household increases its participation and dependence on the market it loses substantial reliance on the farm for its food needs and increases the share of foods purchased from the market, thus increasing

the household's cash needs. As incomes increase, given positive income elasticities for most consumer goods, cash consumption expenditures also increase.

Applications and Empirical Studies

The application of linear programming to farm firm analysis has been exhaustively discussed elsewhere (Beneke and Winterboer, 1973; Heady and Candler, 1958; Lardd and Easkey, 1959; Zuckerman, 1979; Zusman and Amotz, 1965). Applications to developing economies are evident from Ahn, Singh, and Squire (1981) in Korea using a linear farm technology and a vector of output and input prices. Howard N. Barnum and Lyn Squire (1979) used a conventional approach to assess the theoretical significance of introducing the production of nonagricultural goods into a model of household behavior, and to examine the role of labor market participation in determining output and labor supply response. However, no consideration was made for crop consumption decisions. Crawford applied a stochastic linear programming model to representative farming households in Northern Nigeria (Crawford, 1982). Tesfaye (1984) used both linear programming and econometric analysis to examine farming household resource and income uses among representative Ethiopian farming households. Other studies include Strauss, 1981; Yotopolous, Lau, and Liu, 1976; Yotopolous and Lawrence, 1974; and Krishna, 1969.

The main focus in all these studies has been to derive optimum farm production plans, resource demand, supply and uses, various price

relationships, resource availability and technological coefficients, and farm level profitability. It is assumed in all these studies that an active labor market exists and that no distinct difference exists among farming household preferences towards alternative uses of time.

Theoretical Model Formulation

A conventional linear programming model could be formulated as follows:

$$\text{Max } Z = C'X \tag{3.1}$$

subject to:

$$AX \leq (=, \geq)B \tag{3.2}$$

$$X \geq 0 \tag{3.3}$$

where:

Z = value to be maximized,

C = nxl vector of prices,

X = nxl vector of activity levels,

A = mxn matrix of input-output coefficients, and

B = mxl vector of available resources and/or other restrictions.

Assumptions:

(i) both the objective and constraint functions are linear,

(ii) the activities are noninteractive,

(iii) the input-output coefficients are proportional (a right-angle isoquant),

(iv) all coefficients are known with certainty, and

(v) the decision variables are nonnegative (equation 3.3).

The parametric programming model is a modification of the conventional simplex linear programming model presented above and could be presented as follows:

$$\text{Max } Z_{\alpha} = \sum_{j=1}^{\gamma} C_j X_j \tag{3.4}$$

subject to:

$$\sum_{i=1}^{m} a_{ji} X_j \leq (=, \geq) b_i, \tag{3.5}$$

$$X_i \geq 0 \tag{3.6}$$

where:

$$Z = Z(X_1, X_2, \ldots, X_j, \ldots, X_n)$$

$$C_j' \leq C_j \leq C_j''$$

$$C_j'' - C_j' = k \text{ or } \overline{\lambda}$$

$$C_j'' - C_j' = \lambda k$$

Z_{α} = α^{th} objective function to be maximized for a given price (resource) level within the given price (resource) range.

b_i = level of the i^{th} resource available.

C_j' and C_j'' = lower and upper limits of the price (resource) of the j^{th} activity.

λ = constant increment in the price of the j^{th} activity.

k = the number of optimum solutions within the price (resource) range.

The derived solutions (short-run) presuppose that no changes other than product price and/or those specified exogenously occur. It is also

generally assumed that farms have achieved an optimum organization before the series of price changes occur. However, it is generally observed that farmers in the study area and/or developing countries are far from their optimum organization. Under this formulation, it is important to note that the quantity of product supplied and the level of resource demand are not only functions of the prices of output and resources, but the model also considers the array of alternative production enterprises competing for the limited resources and also alternative farm objectives and the level of technology. Note that since they relate to the present asset structure and technological coefficients of the farm, the analysis is essentially static in nature.

Farmers operate in a dynamic world in which not only prices but also technological resource availability change over time. Also, constant product and factor prices given changes in the price of one product and/or factor are strictly short-run phenomenon which assumes complete independence between factors and/or products--a situation not very typical of the agricultural industry. In the real world, many factors or products have competitive, supplementary, and complementary relationships in the production process. For instance, an increase in the producer price of groundnuts which increases significantly its profitability relative to maize ceteris paribus will lead to increased land and resource allocation to groundnuts and a decrease of those resources allocated to maize production. Therefore, in the final analysis there are many combinations of product and resource prices. The formulation of an appropriate long-run price and resource policy requires an

understanding of both the short-run and long-run effects of price changes on resource demand and product supply.

CHAPTER 4. PROGRAMMING MODELS FOR THE STUDY AREA

Adaptation of the Structure of LP Models

Although profit maximization is the assumed objective in determining the normative phase of the analysis, consumption and nutrition requirements are included in the model to reflect the realism characteristic of the area of study. Specifically, the estimated LP model incorporates the following adjustments:

(a) Consumption activities are incorporated in the model to allow the farming household to meet its minimum nutritional requirements.

(b) Minimum nutritional constraints are incorporated into the equations to ensure that the average farming household meets its minimum nutritional requirements.

(c) The resource column for labor supply and capital are adjusted to allow for labor hiring options and credit borrowing activities, respectively.

(d) Draught oxen are used at various stages of the production process under oxen technology. The estimated requirements and their supply are entered in the resource column.

(e) Alternative farm objectives are introduced in the model in order to approximate the farming household's ordered goals and establishment of trade-offs among them (Tesfaye, 1984).

Three goals are treated in this study. The first goal is the "subsistence mode," in which the household produces first for home

consumption with the surplus marketed for cash earnings. Under this formulation, a minimum subsistence food consumption requirement is specified to be met either from on-farm consumption and/or market purchases. The second alternative is the "nutrition mode" under which the farming household is forced to choose crop mixes that meet minimum household nutritional requirements. Finally, is the "market mode" under which it is assumed that the sole objective of the farming household is maximizing income.

The Constraint Structure

The constraint set includes structural (resource) and behavioral constraints. Resource constraints relate to the availability of variable inputs, i.e., family labor, hired labor, and other inputs. They also include availability of quasi-fixed inputs in the form of available cleared land and the use of oxen and oxen implements. They do not encompass fixed costs that go towards purchases of oxen and oxen implements because that option appears to be unprofitable given small cultivable land holdings. The utilization of various inputs is examined in relation to the relevant production periods and/or activities included in the model.

Land constraints

Generally, land is not a limiting factor, however, cultivable land is limiting. Therefore, land is limited by the average acreage of cleared land available to the household.

Labor constraints

There are three distinct seasons incorporated in the model, hence there are three labor constraints for each period (Table 1.1). The sources of farm labor are family labor and labor hiring. The total labor available to the farming household is computed by an age-sex coefficient of worker productivity and the total hours are divided by 6.5 hours to convert them to man-days. Labor availability is discussed in relation to the stipulated periods in the model.

Oxen constraints

Oxen labor is based on hiring a pair of oxen and performing certain field operations. The amount of oxen labor available for hire in a locality is limited during any time period. There are three distinct seasons and, hence, there are three constraints, one for each period (Table 1.1).

Capital and credit constraints

This is a constraint on the cash available to the household for executing activities that use cash by the total cash savings generated from the previous year through the sale of outputs; nonfarm cash earnings excluding any cash consumption expenditures. Seasonal borrowing is included in the model to augment household cash for financing farm operations. Borrowing is limited by an upper bound imposed by the lending agency based on the crop portfolio in the farm plan and does not cover consumption and/or labor hiring activities.

Consumption constraints

These describe the annual domestic food needs of the household composed of on-farm consumption and market purchases of consumer goods. They are defined for a minimum requirement of the average farming household, defined as a fixed function of household composition.

Nutritional constraints

Minimum nutritional requirements are incorporated in the model based on the age and sex structure of the average farming household. A consumer equivalent of four is used to adjust the relevant coefficients on an annual basis.

Coefficients applied to estimate the number of man-equivalent consumer units for the average household[1]

Age	Male (a)	Female (b)	Consumer equivalent units (a+b)
0-4	0.15(1)[2]	0.15(0)	0.30
5-9	0.25(0)	0.25(1)	0.50
10-15	0.55(1)	0.55(1)	1.10
16+	1.00(1)	0.75(2)	1.75
	1.70	2.30	4.00

Activities in the Model

Production activities

Production activities are considered for both handhoe and oxen technology. They define the set and sequence of agricultural tasks that

[1]Source: Compiled by the author.

[2]The figures in the parentheses show the number of household members in the age groups.

have to be accomplished by the household in order to realize final outputs. The pattern and rate at which these tasks are undertaken is influenced by weather conditions, cropping pattern, crop mix, resource availability to the household, and the technology set known and available to the household. These tasks are associated with:

(a) A unit cost associated with a particular task accounting for all the costs of the subset of tasks included in the model.

(b) An intermediate or final output per unit level of the activity.

(c) Input coefficients defining the level of use of various physical and financial resources.

Most field operations can be performed by either handhoe, oxen technology, or a combination of both. Associated with each task is a performance rate defining the time it takes to be completed, while it says nothing about the quality of work performed. This permits a thorough examination of the input-output structure and the transformation process. Production activities are associated with a vector of costs or return input-output coefficients. The coefficients are incorporated in the model such that production operations depict a fixed input-output structure representing intermediate production activities.

The organization of agricultural operations permits a one directional flow of resource use. This is consistent with linear programming algorithm which treats the entire period as a single point in time without making a distinction between the beginning and the end of a period (Singh, 1971). This requirement is not fully accomplished in this model, however its significance lies in the fact that it prevents expenses from being paid from income not yet received. Each production

activity is defined in terms of its share of total cropped land, the share of the crop in the household diet, and its income generating capability.

Buying and selling activities

These involve the purchase and use of variable inputs which depend among others on:

(i) Type and scope of production activities undertaken by the household.

(ii) Relative marginal productivities in various uses which in turn depends on production alternatives available to the household.

(iii) Availability of farm inputs to the household in the appropriate quantities and on a timely basis.

The use of variable inputs demonstrates the interdependence between the farm and the household. The household's own resources are consumed by the farm with the appropriate opportunity cost. The use of the household's own resources differs from the range of other resources in that no cash exchange takes place.

Buying and selling activities also involve the purchase of consumer goods over and above on-farm retention, necessary for meeting minimum nutritional requirements and other family expenses. Furthermore, they include the disposition of farm outputs through the formal marketing channels. The prices used relate to the 1981-82 agricultural season.

Labor activities

Labor activities involve family labor and labor hiring activities. The inputs of family labor are given a zero marginal cost in the

objective function because it is assumed that consumption and nutritional constraints account implicitly for its internal cost. The opportunity cost of labor is determined by off-farm wages. There are differential wages reflecting the type of task performed and the age of the worker. However, in this study the government mandated minimum wage rate is employed for labor hiring activities in the objective function.

Capital borrowing activities

Given that owner financing is limited, borrowing activities are incorporated in the model to finance farm input purchases (i.e., seed, fertilizers, chemicals) but borrowed capital cannot be used to cover labor hiring activities. The interest rate is 9.5 percent. Credit from relatives, friends, and local money lenders has not been incorporated in the model because of data inadequacies. Borrowing activities have been incorporated in the model in order to examine the criticalness of credit facilities to scale operation and farm incomes. Transfer activities are incorporated to transfer capital from the household's own savings, and borrowed capital to farm operating expenses.

Consumption activities

These activities are associated with household consumption needs of:

(i) Food grain and food items from the household's production process.

(ii) Consumption of purchased goods.

The principal component of consumption is grain from either source

mentioned above. Consumption is given a zero cost in the objective function.

Nutrition restraints and activities

The restraints seek to define the minimum nutritional requirements of the household, the activities define how requirements can be met from on-farm consumption, market purchases, or a combination of both. The activities provide a close accounting of the kinds, amounts, and composition of foods available to the household. The interaction of these activities with all other activities plus restraints determines the household's choices regarding food sources.

Mathematical Statement of the LP Model

The mathematical model of the typical farming household could be stated as follows:

Objective function

$$\text{Max } \Pi = \sum_j P_j X_j - \sum_j C_j X_j - \sum_i w_i LH_i - \sum_i \alpha_i OH_i - \sum_i \gamma_i \beta_i \qquad (3.7)$$

where:

Π = net farm cash income in kwacha,

P_j = the unit selling price of the j^{th} farm produce in kwacha per kg,

X_j = level of the j^{th} production process in kg,

C_j = variable cash costs for the j^{th} production activity in kwacha per acre,

w_i = wage rate per man-day in the i^{th} season in kwacha,

LH_i = labor hired in the i^{th} season in man-days,

α_i = cost of hiring oxen use in the i^{th} season in oxen-days,

OH_i = oxen hiring level in the i^{th} season in oxen-days,

γ_i = annual rate of interest in percentage for borrowing capital for production, and

β_i = amount of capital borrowed for various farm uses in kwacha,

subject to:

Land constraints

$$\sum_j a_j X_j \leq LA \tag{3.8}$$

where:

a_j = quantity of land required per unit of the j^{th} production process in acres, and

LA = amount of cleared cultivable land available to the household in acres.

Labor constraints

$$\text{(i)} \quad \sum_i \overline{LF}_i \geq \sum_{ji} e_{ji} X_{ji} - \sum_{ji} LH_{ji}, \tag{3.9a}$$

$$\text{(ii)} \quad \sum_i LF_i \geq \sum_{ji} e_{ji} X_{ji} \text{ or } \sum_i LF_i = \sum_i \overline{LF}_i + \sum_i LH_i \tag{3.9b}$$

where:

$\overline{LF}_i$ = amount of adjusted family labor available in the i^{th} season in man-days exogenously determined,

LF_i = amount of labor resource available in the i^{th} season for farming activities, and

e_{ji} = amount of labor required in the i^{th} season per unit of the j^{th} production activity.

Oxen constraints

$$\text{(i)} \quad \sum_i \overline{OF}_i \geq \sum_{ji} m_{ji} X_{ji} - \sum_{ji} OH_{ji} \tag{3.10a}$$

$$\text{(ii)} \quad \sum_i \overline{OF}_i \geq \sum_{ji} m_{ji} X_{ji} - \sum_{ji} OH_{ji} \text{ or } \sum_i OF_i \geq \sum_{ji} m_{ji} X_{ji} \tag{3.10b}$$

where:

$\overline{OF}_i$ = amount of oxen-days available in the i^{th} season, exogenously determined,

m_{ji} = per unit oxen labor requirements by the j^{th} production activity in the i^{th} season, and

OF_i = amount of oxen labor resource available in the i^{th} season.

Capital and credit constraints

$$\text{(i)} \quad \overline{KH} \geq \sum_j k_j X_j - \sum_j \beta_j \tag{3.11a}$$

$$\text{(ii)} \quad KH = \overline{KH} + \sum_j \beta_j \tag{3.11b}$$

where:

$\overline{KH}$ = amount of owner's working capital initially available in kwacha,

k_j = amount of working capital required per unit of the j^{th} production activity in kwacha, and

KH = amount of working capital available in kwacha.

On-farm consumption constraints

$$R_j \leq r_j X_j \tag{3.12}$$

where:

R_j = a minimum household consumption requirement for the j^{th} farm produce in kg, and

r_j = a fraction of output per unit of production j retained for domestic consumption in kg.

Nutrition constraints

$$N_{tj} \leq d_{tj} X_j \tag{3.13}$$

where:

N_{tj} = the total amount of nutrients for type t from consuming the j^{th} farm produce in standard units, and

d_{tj} = the amount of nutrients of type t supplied per unit of consumption of crop j.

Crop production equilibrium condition

$$y_j X_j - R_j X_j - M_j = 0 \tag{3.14}$$

where:

y_j = average yields of the j^{th} production activity in kg,

R_j = amount of the j^{th} produce required for family consumption needs in kg, and

M_j = marketing level of the j^{th} farm produce in kg.

A schematic summary of these equations is presented in Figure 4.1, showing the activities, resource constraints, and the technical coefficients.

Empirical Results and Analysis

Handhoe technology

In this section, the effects of alternative farm objectives are examined in relation to:

(i) choice and ranking of crop and consumption mixes,

(ii) cash farm income and associated trade-offs in income earnings, and

(iii) resource uses and their respective returns.

Crop mixes Given the state of technology, behavioral and structural restrictions, the average farming household under subsistence and nutrition modes responds by producing the following crops in the following ranking: maize, groundnuts, and beans. The production of beans is only limited to meeting the minimum consumption and nutritional requirements. This is consistent with observed practices where beans have become a minor crop produced from fields close to homesteads and/or intercropped with major crops, e.g., maize, etc. Beans drop out of the basic solution as the household adopts a pure income maximization alternative (i.e., the market model) (Table 4.1).

Choice of consumption bundles Maize is the dominant food crop followed by groundnuts and beans as supplements. The dominancy of maize

Activities / Constraints	Production[a]		Capital		Marketing		Purchases		Consumption		Labor Hiring				Labor Oxen	Row type	RHS resource supply
	Maize	Beans	Borrow	Transfer	Maize	Beans	Maize	Beans	Maize	Beans	August-November	December-May	June-July				
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13		P14		
Objective function	-	-	-	θ	+	+	-	-	θ	θ	-	-	-		-	N	
subject to:																	
Land:																	
R01	a	a														L	B1
Labor:																	
R02	a	a									-1					L	B2
R03	a	a										-1				L	B3
R04	a	a											-1			L	B4
R05	a	a													-1	L	0
R06															1	L	B6
Capital:																	
R07				-1												L	B7
R08			1													L	B8
R09	a	a	-1	-1												L	0
R10			1	1												L	B10
Output balances:																	
R11	-b				1		-1		1							L	0
R12		-b				1		-1		1						L	0
Consumption const.:																	
R13									1							G	B13
R14										1						G	B14
Nutrition const.:																	
R15									a	a						G	B15
R16									a	a						G	B16

[a] a or +1: per unit requirement level; -b or -1: per unit supply level; N = objective function or nonrestrictive row; L = maximum restraint (les than or equal to); G = minimum restraint (greater than or equal to).

Figure 4.1. LP model formulation: A schematic representation

Table 4.1. A summary of results on return and uses of resources: Handhoe technology[a]

	Subsistence mode	Nutrition mode	Market mode
A. Maximand value	292.04	170.24	592.65
B. Activity level			
1. Production (acres):			
Maize	7.17	5.64	7.43
Beans	0.20	1.35	-
Groundnuts	0.33	2.70	2.27
Cotton			
Sunflowers			
2. On-farm consumption (kgs):			
Maize	1266.00	1777.70	
Beans	31.00	209.39	
Groundnuts	96.00		
3. Purchases (kgs):			
Maize			
Beans			
Groundnuts			
4. Sales (kgs):			
Maize	1547.84	438.91	2917.62
Beans			
Groundnuts	394.16	567.87	476.65
Cotton			
Sunflowers			
5. Borrowing (K):	196.13	222.12	191.97
C. Resource used			
1. Land (acres)[b]	9.70	9.70	9.70
	(1.00)	(1.00)	(1.00)
2. Labor			
(i) August-Nov (MD)[b]	195.58	181.04	198.10
	(0.43)	(0.40)	(0.44)
(ii) Dec-May (MD)[b]	424.87	524.90	407.50
	(0.37)	(0.46)	(0.36)
(iii) June-July (MD)[b]	308.71	308.71	308.71
	(1.00)	(1.00)	(1.00)
3. Financial capital (K)[b]	214.13	240.12	209.97
	(0.28)	(0.31)	(0.27)

[a]Source: LP runs.

[b]Figures in parentheses are shares; MD = man-days; K = Zambian kwacha currency.

Table 4.1. Continued

	Subsistence mode		Nutrition mode		Market mode	
D. Resource at limit	MVP	Range	MVP	Range	MVP	Range
1. Land (K/acre)	43.34	(6.72-15.54)	43.29	(8.85-18.11)	43.34	(4.08-16.76)
2. Labor (June-July)	0.55	(210.18-534.54)	0.53	(153.79-372.75)	0.55	(178.67-734.39)
3. Capital:equity	0.095	(0.00-214.13)	0.095	(0.00-240.12)	0.095	(0.00-209.97)
E. Unit cash return:						
1. Land (K/acre)		30.11		17.55		61.10
2. Family labor (K/MD)		0.31		0.17		0.65
3. Financial capital		1.36		0.71		2.82
F. Cash income trade-offs:						
1. Subsistence mode		1.00		0.58		2.03
2. Nutrition mode				1.00		3.48
3. Market mode						1.00

becomes more pronounced under the nutrition mode with groundnuts becoming the sole supplement. This is because groundnuts provide more and cheaper sources of nutrients per unit of consumption than beans (Table 2.11). Furthermore, as shown below the ratio of producer to consumer prices favors groundnuts over beans.

Cash farm income Maize is the dominant source of cash income followed by groundnuts in all but the nutrition mode. Under the nutrition mode, groundnuts become dominant over maize as a source of income. Given the resources available to the household--cultivable land, in particular, consumption, and nutrition requirements--the revealed preferences of farming households indicate that there is limited scope for market participation. This is important not only because of existing supply limitations for basic consumer goods in most parts of rural Zambia, but more so due to higher consumer prices relative to producer prices received by farming households as demonstrated by the following proportions--0.67, 0.11 and 0.24 for maize, beans, and groundnuts, respectively. Under the subsistence mode, minimum consumption needs reduce the level of marketable surplus for maize and groundnuts by 44.9 and 19.59 percent, respectively. Similarly, under the nutrition mode, marketable surplus is reduced by 80.20 and 26.94 percent for maize and groundnuts, respectively (Table 4.1).

An examination of the levels of cash incomes shows that first, as the constraints become less binding, the farming household's cash income increases. Secondly, the average farming household prefers to produce rather than to obtain from the market those food crops necessary for

meeting consumption and nutritional requirements. Therefore, consumption requirements not only reduce the degree of specialization and commercialization of agricultural production but also lower the levels of cash earnings (Table 4.1).

The cash income trade-off between the alternative farm objectives helps to illustrate the impact of production plans on cash income earnings as a measure of foregone income (Tesfaye, 1984). This entails an assessment of the amount of cash income (in kwacha) gained per unit of income lost as the average farming household moves from alternative farm objectives to pure income maximization. From Table 4.1 it is clear that the average farming household benefits more by shifting to the market mode. The household gains more by shifting from the nutrition mode to the market model. For every one kwacha lost by shifting from nutrition mode to market mode, the farming household gains K3.48. Assuming the welfare of farming households is measured in terms of cash generating capacity, the pure income maximization alternative is the dominant objective.

Resource uses and returns Where a farming household is assumed to operate with 9.70 acres of land, K18.00 of equity capital, and 1898.67 man-days of labor broken into three distinct production seasons, the shadow prices show that cultivable land is the most limiting factor to increased crop production and farm incomes. Under these assumptions, an increase in the amount of cultivable land available to the household would increase farm income by approximately K43.00. The sensitivity of cash income to changes in area of cultivable land available shows that

the subsistence model responds more rigorously to land adjustments (Table 4.1).

The employment rates (Table 4.2) show a seasonal and occupational pattern. In all cases but the nutrition mode, employment rates are lowest during the December-May season and highest during the June-July season (100 percent) under all farm objectives with a positive shadow price of K0.55. There is, however, a shift in the pattern of labor utilization during all seasons except the June-July season relative to farm objectives. This structural shift could be explained by the changes in crop mixes and land allocation decisions associated with each farm objective.

It should be pointed out that the model was constructed in such a way that it was not possible to show employment rates on a monthly basis.

Table 4.2. Employment rates of family labor and shadow prices[a]

Mode	Production seasons		
	August-November	December-May	June-July
Subsistence	43.25	37.34	100.00 (0.55)[b]
Nutrition	40.04	46.13	100.00 (0.55)
Market	43.81	35.82	100.00 (0.55)

[a]Source: LP runs.

[b]The figures in parentheses are shadow prices.

Such estimates would enhance our understanding of the labor restrictions in relation to adoption of improved farming practices and oxen technology. Returns to family labor are fairly low under all farm objectives ranging from K0.17 under the nutrition mode to K0.65 under the market mode, lower than the government mandated minimum rural wage rate of K2.00 per man-day (Table 4.1). This is due among other causes to low yields, inefficiently small fields, and lack of alternative employment opportunities. Return to land is highest under the market mode.

The credit needs of the average farming household reflects the crop portfolio in the production plans. Given the state of technology, the borrowing level ranges from K191.97 to K196.13. The borrowing level is lowest under the market mode because of the existence of production activities in the crop plan that require less cash inputs but provide a higher cash return.

Evidence from elasticity coefficients (Table 4.3) suggests that income is more sensitive to changes in the size of fields. A comparative analysis shows that the sensitivity is highest under the nutrition mode.

Table 4.3. Elasticities: Handhoe technology[a]

	Subsistence mode	Nutrition mode	Market mode
Land	1.44	2.47	0.71
Labor: June-July	0.58	1.00	0.29
Capital:equity	0.01	0.01	0.003

[a]Source: Computed from LP runs.

Oxen technology: Hiring option

Crop mixes Given oxen technology's (hiring option) behavioral and structural restrictions, the average household under subsistence the mode produces the following crops according to the following ranking: maize, groundnuts, and beans. Maize is the predominant crop under all alternatives. Groundnuts drops out of the solution under the nutrition mode while maize is the sole crop produced under the market mode.

Choice of consumption bundles Maize is the basic food crop followed by groundnuts and beans as supplements. Under the nutrition mode, beans is the sole supplement. This is because beans is a cheaper source of nutrients.

Cash farm income Maize is the sole source of cash income while beans and groundnuts production are only limited to meeting minimum consumption and nutritional requirements. Given the constraint structure and resource availability to the household, the revealed preferences of the farming households show limited market participation. Consumption requirements are met through on-farm retention instead of market purchases. This is important because of existing supply limitations of basic food stuffs through the market mechanism in most of rural Zambia and because of higher consumer prices relative to producer prices as indicated earlier. Under the subsistence mode, minimum consumption requirements reduce marketable surplus for maize by 17 percent and by 25 percent under the nutrition mode (Table 4.4).

The relaxation of constraints leads to increased cash income earning capacity. Cash income trade-offs between alternative farm objectives

Table 4.4. A summary of results on return and uses of resources: Oxen technology (hiring option)[a]

	Subsistence mode	Nutrition mode	Market mode
A. Maximand value	108.13	5.19	405.53
B. Activity level			
1. Production (acres):			
Maize	9.17	8.62	9.70
Beans	0.16	1.08	
Groundnuts	0.37		
Cotton			
Sunflowers			
2. On-farm consumption (kgs):			
Maize	1266.00	1777.70	
Beans	31.00	209.39	
Groundnuts	96.00		
3. Purchases (kgs):			
Maize			
Beans			
Groundnuts			
4. Sales (kgs):			
Maize	6210.45	5246.87	7905.50
Beans			
Groundnuts			
Cotton			
Sunflowers			
5. Borrowing (K):	166.63	164.20	149.33
C. Resource used			
1. Land (acres)[b]	9.70	9.70	9.70
	(1.00)	(1.00)	(1.00)
2. Labor			
(i) August-Nov (MD)[b]	69.80	61.56	65.57
	(0.15)	(0.14)	(0.15)
(ii) Dec-May (MD)[b]	198.84	191.24	189.44
	(0.17)	(0.17)	(0.17)
(iii) June-July (MD)[b]	184.76	160.49	180.61
	(0.60)	(0.52)	(0.59)
(iv) Oxen:labor (OD)[b]	80.63	73.95	83.23
	(0.38)	(0.35)	(0.39)

[a]Source: LP runs.

[b]Figures in parentheses are shares; MD = man-days; K = Zambian kwacha currency; OD = oxen-days.

Table 4.4. Continued

	Subsistence mode		Nutrition mode		Market mode	
3. Financial capital (K)[b]	184.63 (0.24)		182.20 (0.24)		167.33 (0.22)	
D. Resource at limit	MVP	Range	MVP	Range	MVP	Range
1. Land (K/acre)	41.63	(2.08-16.36)	41.63	(3.26-17.66)	41.63	(1.04-16.58)
2. Capital:equity	0.095	(0.00-184.63)	0.095	(0.00-73.95)	0.095	(0.00-167.32)
E. Unit cash return:						
1. Land (K/acre)	11.15		0.54		41.81	
2. Family labor (K/MD)	0.24		0.01		0.93	
3. Financial capital	0.59		0.03		2.42	
4. Oxen labor (K/OD)	1.34		0.07		4.87	
F. Cash income trade-offs:						
1. Subsistence mode	1.00		0.05		3.75	
2. Nutrition mode			1.00		78.14	
3. Market mode					1.00	

shows the household gains more by shifting from nutrition to the market mode by a factor of 78.14 (Table 4.4).

Resource uses and returns Land and equity capital are the limiting factors to increased crop production and farm incomes. The shadow prices show that an increase in the amount of cultivable land available to the household would increase farm income by K41.63. Cash income is more sensitive to changes in size of fields under the market mode (Table 4.4).

The employment rates for family labor range from as low as 14 percent under the nutrition mode during the December-May season to as high as 60 percent under the subsistence mode during the June-July season. Oxen labor utilization remains steady around 37 percent under all farm alternatives. Returns to land, family labor, oxen labor, and financial capital are lowest under the nutrition mode and highest under the market mode (Table 4.4). The borrowing level reflects the low level of equity and lower use of cash inputs and ranges from as low as K149.33 under the market mode to as high as K166.63 under the subsistence mode. Evidence from elasticity coefficients suggests that income is more sensitive to changes in the size of fields than to changes in equity. The sensitivity is highest under the nutrition mode.

Oxen technology: Owning option

Crop mixes Maize is the dominant crop under the subsistence mode while beans and groundnuts drop out of the solution under both nutrition and market modes.

Choice of consumption bundles Maize is the basic food crop under the subsistence mode while groundnuts and beans are supplements. Consumption is only limited to maize under the nutrition mode. On-farm consumption is preferred over market participation. Minimum consumption requirements reduce marketable surplus by 17 percent and by 31 percent under the subsistence and nutrition modes, respectively. As the farming household shifts towards the market mode with less binding constraints, cash income earning capability of the household is enhanced (Table 4.5). The cash income trade-offs show that the household gains more by shifting from the nutrition mode to market mode by a factor of 1.73.

Resource uses and returns Land is the most limiting factor. The shadow prices suggest that an increase in the amount of tillable land by one acre would increase farm income by K107.61. Cash income is more sensitive to changes in land restraint under the market mode.

Family labor employment rates range from as low as 15 percent under all farm alternatives during the August-November season to about 60 percent during the June-July season. The oxen employment rate is stable at approximately 39 percent. The credit borrowing level is the same as under the hiring option. Elasticity coefficients (Table 4.6) suggest that income is more sensitive to changes in field sizes under the nutrition mode.

Parametric Results and Analysis

Interest rate policy

In this section, we investigate the effects of changes in the interest rate, producer prices, and reduction in the level of input

Table 4.5. A summary of results on return and uses of resources: Oxen technology (owning option)[a]

	Subsistence mode	Nutrition mode	Market mode
A. Maximand value	728.14	604.94	1045.54
B. Activity level			
1. Production (acres):			
Maize	9.17	9.70	9.70
Beans	0.16		
Groundnuts	0.37		
Cotton			
Sunflowers			
2. On-farm consumption (kgs):			
Maize	1266.00	2447.00	
Beans	31.00		
Groundnuts	96.00		
3. Purchases (kgs):			
Maize			
Beans			
Groundnuts			
4. Sales (kgs):			
Maize	6210.45	5457.75	7905.50
Beans			
Groundnuts			
Cotton			
Sunflowers			
5. Borrowing (K):	166.63	149.33	149.33
C. Resource used			
1. Land (acres)[b]	9.70	9.70	9.70
	(1.00)	(1.00)	(1.00)
2. Labor			
(i) August-Nov (MD)[b]	69.80	65.57	65.57
	(0.15)	(0.15)	(0.15)
(ii) Dec-May (MD)[b]	198.84	189.44	189.44
	(0.17)	(0.17)	(0.17)
(iii) June-July (MD)[b]	184.76	180.61	180.61
	(0.60)	(0.59)	(0.59)
(iv) Oxen:labor (OD)[b]	80.63	83.23	83.23
	(0.38)	(0.39)	(0.39)

[a]Source: LP runs.

[b]Figures in parentheses are shares; MD = man-days; K = Zambian kwacha currency; OD = oxen-days.

Table 4.5. Continued

	Subsistence mode		Nutrition mode		Market mode	
3. Financial capital (K)[b]	184.63 (0.24)		167.33 (0.22)		167.33 (0.22)	
D. Resource at limit	MVP	Range	MVP	Range	MVP	Range
1. Land (K/acre)	107.61	(2.08-16.36)	107.61	(3.00-16.58)	107.61	(1.04-16.58)
2. Labor (June-July)	0.095	(0.00-184.63)	0.095	(0.00-167.32)	0.095	(0.00-167.33)
E. Unit cash return:						
1. Land (K/acre)	75.07		62.36		107.79	
2. Family labor (K/MD)	1.61		1.39		2.40	
3. Financial capital	3.94		3.62		6.25	
4. Oxen labor (K/OD)	9.03		7.27		12.56	
F. Cash income trade-offs:						
1. Subsistence mode	1.00		0.83		1.44	
2. Nutrition mode			1.00		1.73	
3. Market mode					1.00	

Table 4.6. Elasticities: Oxen technology[a,b]

	Subsistence IIa	Mode IIb	Nutrition IIa	Mode IIb	Market IIa	Mode IIb
Land	3.73	1.43	77.81	1.73	1.00	1.00
Capital:equity	0.02	0.002	0.33	0.003	0.004	0.002

[a]Source: LP runs.

[b]IIa = oxen technology (hiring option); IIb = oxen technology (owning option).

subsidy costs. Specifically, we note that the nominal interest rates have tended to be low relative to the rate of inflation (i.e., the real rates of interest adjusted for the expected rate of inflation have been negative). In 1982, the prime loan rate was 9.5 percent; adjusted by a high income consumer price inflation of 13.2 percent results in a -3.7 prime loan rate. These rates, however, underestimate the real cost of borrowing because they exclude handling charges, application fees, commitment fees, penalties on overdrawn loan accounts, and fees for local purchase orders (LPSs) for credit-in-kind transactions. Furthermore, the interest rates are raised by charging interest on a longer period than the actual duration of the loan, for example, the AFC and CCF charge interest for 12 months while repayment is to be made in nine months (GRZ:MAWD, 1983a). The consequences of such low rates of interest have been overmechanization of commercial agriculture, low savings rates, and inefficient utilization of resources.

Subsidy policy In 1982, fertilizer prices to the farmers were subsidized at an average of 37 percent of real cost. Note that this refers to direct subsidy. The real level of subsidy could be higher if consideration is made for indirect effects of low rates of interest, research costs, etc. However, if these direct subsidies were withdrawn, it would increase the price of fertilizer by 59 percent. The cost of production of most crops would go up by approximately ten percent for large-scale commercial farmers while it is estimated that it would be less for small-scale farmers due to lower use of cash inputs (GRZ:MAWD, 1981b).

Pricing policy The government until recently has been following a policy of administered prices based on the cost of production and marketing margins. This policy, as mentioned earlier, has constantly come under attack. The prices have been deemed low and hence led to distortions in production.

Results The results in this section are not based on individual policy change but rather on a policy package of:

(i) an increase in the cost of borrowing to 13 percent,

(ii) an increase in the production cost (subsidy reduction) by ten percent, and

(iii) an increase in producer prices from 1982 to 1983 prices.

Handhoe technology

Given the policy package and the constraint set, there is no change in the crop mix under all farm alternatives. On-farm consumption remains

unchanged both in terms of source and as a percentage of total production (Table 4.7). Maize remains the dominant source of cash income. The cash income trade-off indicates that the farmer gains more by shifting from the nutrition mode to the market mode. Returns to resources are highest under the market mode. Land remains the most significant limiting factor to increased agricultural production and farm incomes. The shadow price indicates that a one-acre increase in the amount of land available to the household would increase farm income by K46.32, not significantly different from the basic results (Table 4.1) and the relevant ranges over which the shadow price is constant remains the same under all farm objectives.

Oxen technology: Hiring option

The average farming household under these changes would respond under the subsistence mode by producing the following crops in the following ranking: groundnuts, maize, and beans. Groundnuts becomes the predominant crop while beans is only produced to meet household minimum consumption requirements. Groundnuts remains the dominant crop in the other alternative modes while beans drops out (Table 4.8).

Maize is still the basic food crop with groundnuts as the sole supplement under the nutrition mode. Groundnuts becomes the dominant source of cash income under all farm objectives but in the market mode maize still remains the sole source of income. Consumption requirements continue to be met from on-farm consumption rather than market purchases.

Table 4.7. Parametric results of interest rate, subsidy reduction, and producer price increase on returns and uses of resources: Handhoe technology[a]

	Subsistence mode	Nutrition mode	Market mode
A. Maximand value	328.49	196.79	664.55
B. Activity level			
1. Production (acres):			
Maize	7.17	5.65	7.43
Beans	0.20	1.35	
Groundnuts	2.33	2.70	2.27
Cotton			
Sunflowers			
2. On-farm consumption (kgs):			
Maize	1266.00	1777.70	
Beans	31.00	209.39	
Groundnuts	96.00		
3. Purchases (kgs):			
Maize			
Beans			
Groundnuts			
4. Sales (kgs):			
Maize	1547.84	438.91	2917.62
Beans			
Groundnuts	394.16	567.88	476.65
Cotton			
Sunflowers			
5. Borrowing (K):	216.59	242.94	212.01
C. Resource used			
1. Land (acres)[b]	9.70	9.70	9.70
	(1.00)	(1.00)	(1.00)
2. Labor			
(i) August-Nov (MD)[b]	195.58	181.04	198.10
	(1.00)	(0.40)	(0.44)
(ii) Dec-May (MD)[b]	424.88	524.90	407.50
	(0.37)	(0.46)	(0.36)
(iii) June-July (MD)[b]	308.71	308.71	308.71
	(1.00)	(1.00)	(1.00)

[a]Source: LP runs.

[b]Figures in parentheses are shares; MD = man-days; K = Zambian kwacha currency; OD = oxen-days.

Table 4.7. Continued

	Subsistence mode		Nutrition mode		Market mode	
3. Financial capital (K)[b]	234.95 (0.31)		260.93 (0.34)		230.01 (0.30)	
D. Resource at limit	MVP	Range	MVP	Range	MVP	Range
1. Land (K/acre)	46.32	(6.72-15.54)	46.32	(8.85-18.11)	46.32	(4.01-16.76)
2. Labor (June-July)	0.69	(201.18-534.54)	0.69	(153.79-372.75)	0.69	(178.67-734.39)
3. Capital:equity	0.13	(0.00-234.59)	0.13	(0.00-260.93)	0.13	(0.00-230.01)
E. Unit cash return:						
1. Land (K/acre)	33.86		20.29		68.51	
2. Family labor (K/MD)	0.35		0.19		0.58	
3. Financial capital	1.40		0.75		2.89	
F. Cash income trade-offs:						
1. Subsistence mode	1.00		0.60		2.02	
2. Nutrition mode			1.00		3.38	
3. Market mode					1.00	

Table 4.8. Parametric results of interest rate, subsidy reduction, and producer price increase on returns and uses of resources: Oxen technology[a]

	Subsistence mode		Nutrition mode		Market mode	
	IIa	IIb	IIa	IIb	IIa	IIb
A. Maximand value	208.07	825.48	66.05	691.34	548.50	1180.89
B. Activity level						
1. Production (acres):						
Maize	2.80	9.17	3.11	9.70	3.11	9.70
Beans	0.16	0.16				
Groundnuts	6.74	0.37	6.60		6.60	
Cotton						
Sunflowers						
2. On-farm consumption (kgs):						
Maize	1266.00	1266.00	1595.76	2447.75		
Beans	31.00	31.00				
Groundnuts	96.00	96.00	236.67			
3. Purchases (kgs):						
Maize						
Beans						
Groundnuts						
4. Sales (kgs):						
Maize	1013.88	6210.45	939.46	5457.75	2535.22	7905.50
Beans						
Groundnuts	1670.55		1489.73		1726.40	
Cotton						
Sunflowers						
5. Borrowing (K):	472.71	183.87	463.34	164.85	463.34	164.85
C. Resource used						
1. Land (acres)[b]	9.70	9.70	9.70	9.70	9.70	9.70
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
2. Labor:						
(i) Aug-Nov (MD)[b]	153.78	69.80	152.35	65.57	152.35	65.57
	(0.34)	(0.15)	(0.34)	(0.15)	(0.34)	(0.15)
(ii) Dec-May (MD)[b]	357.87	198.84	353.78	189.44	353.78	189.44
	(0.31)	(0.17)	(0.31)	(0.17)	(0.31)	(0.17)
(iii) June-July (MD)[b]	308.71	184.76	308.71	180.61	308.71	180.61
	(1.00)	(0.60)	(1.00)	(0.59)	(1.00)	(0.59)

[a]Source: LP runs.

[b]Figures in parentheses are shares; MD = man-days; K = Zambian kwacha currency; OD = oxen-days.

Table 4.8. Continued

	Subsistence mode		Nutrition mode		Market mode	
	IIa	IIb	IIa	IIb	IIa	IIb
(iv) Oxen:labor (OD)[b]	59.89	81.25	61.15	83.23	61.15	83.23
	(0.28)	(0.38)	(0.29)	(0.39)	(0.29)	(0.39)
3. Financial capital (K)[b]	490.71	201.87	481.34	182.85	481.34	182.85
	(0.64)	(0.26)	(0.63)	(0.24)	(0.63)	(0.24)
D. Resource at limit	MVP	MVP	MVP	MVP	MVP	MVP
1. Land (K/acre)	54.41	121.50	54.41	121.50	54.41	121.50
2. Labor (June-July)	0.06		0.06		0.60	
3. Capital:equity	0.13	0.13	0.13	0.13	0.13	0.13
	Range	Range	Range	Range	Range	Range
1. Land (K/acre)	(9.06-	(2.08-	(9.11-	(3.00-	(8.11-	(0.95-
	16.36)	16.36)	15.04)	16.58)	16.58)	16.57)
2. Labor (June-July)	(184.76-		(198.17-		(180.61-	
	332.89)		331.12)		369.18)	
3. Capital:equity	(0.00-	(0.00-	(0.00-	(0.00-	(0.00-	(0.00-
	490.71)	201.87)	481.34)	182.84)	481.34)	182.84)
E. Unit cash return:						
1. Land (K/acre)	21.45	85.10	6.81	71.27	56.55	121.74
2. Family labor (K/MD)	0.25	1.82	0.08	1.59	0.67	2.71
3. Financial capital	0.42	4.09	0.14	3.78	1.14	6.46
4. Oxen labor (K/OD)	3.47	10.16	1.08	8.31	8.97	14.19
F. Cash income trade-offs:						
1. Subsistence mode	1.00	1.00	0.32	0.84	2.64	1.43
2. Nutrition mode			1.00	1.00	8.30	1.71
3. Market mode					1.00	1.00

Consumption requirements reduce the level of marketable surplus by 55.53 percent, an increase of 39 percent over the basic run for maize under the subsistence mode and by 63 percent under the nutrition mode--an increase of 38 percent over the basic run. Groundnuts consumption reduces marketable surplus by 5.43 percent under the subsistence mode and by 14 percent under the nutrition mode. The cash income trade-offs show that for every kwacha lost by shifting from the nutrition mode to the market mode the farming household gains 8.30.

Land is the most limiting factor to increased agricultural production and farm incomes. The shadow prices show that a one acre increase in the amount of cultivable land available to the household would increase farm income by K54.41--an increase of 31 percent over the basic run. There is a slight increase in the utilization of labor and a decline in the employment level for oxen labor under all alternatives. Incomes remain more sensitive to changes in the amount of land than to changes in equity, the sensitivity being highest under the nutrition mode.

CHAPTER 5. SUMMARY AND CONCLUSIONS

Summary

This study has been an attempt to contribute towards the knowledge and information necessary to understanding the decision making behavior of farming households. This has been achieved by applying analytical tools and examining the results in terms of the farm structure, the pattern of price response, the economic organization, and motivations of farming households. Also, based on the results, the study has attempted to evaluate the potential of agricultural programs on the volume of production, farm incomes, sources and composition of consumption bundles, nutrition, and general welfare of those households. The results of the study indicate that prevailing interest, pricing, and subsidy practices are not optimal practices. The existing practices all lead to low returns to resources, hence, in the presence of alternative sources of income, farmers would shift from commercial agricultural production.

The results indicate that given farm incomes and prevailing producer and consumer prices, farms prefer on-farm consumption to market purchases. This is important not only because of the observed supply bottlenecks in most of rural Zambia but also because of subsistence agriculture's dependence on weather conditions whose uncertainty causes an element of risk in terms of food shortages. The nutritional effects have only been limited to calories and proteins. Incorporation of other nutrients indicate that the farming households would not be able to meet

the basic minimum of any relevant nutrient. Therefore, although incomes go up, the nutritional status of households does not necessarily increase. Note that this was a crop model; it did not include off-farm and livestock incomes. The results are, therefore, only relevant to pure crop farms.

Conclusions

The analysis has highlighted the most important features influencing the decision making behavior of small-scale farmers in Zambia. The household decides on the mix of crops to be produced. The household provides the bulk of the labor input requirements, while its allocation to specific crops depends on other uses of time (i.e., off-farm employment and expected incomes, crop portfolio of the technology available to the farming household, and the nature of field operations and the rainfall pattern because of agricultural operation's dependency on the timely commencement of the rainfall season). From the study, land allocation decisions to specific crops seem to be influenced by consumption requirements and income generating capability of a given crop. This unified decision process, production-consumption, has formed the central theme for the formulation of this study.

However, it is felt that further work needs to be done. This will largely depend on availability and adequacy of data. Specific issues to be investigated include:

(i) Categorizing farming households in terms of size of operation, resource endowment, family size and composition, and location.

(ii) Categorizing farming households in terms of production activities, crop, livestock production and off-farm employment, and a combination of both.

(iii) Categorizing crop enterprises according to the cropping practices, mono cropping, mixed cropping, and technology set.

These categories will allow for the development of recommendations specific to the level of farm operation, examine competition for resources between on-farm and off-farm activities (e.g, family labor), and compare the competitiveness of mono cropping and mixed cropping and their implications for adoption of improved technology (e.g., oxenization of certain field operations). Finally, a more detailed and rigorous examination of the nutritional status of farming households is required according to the categories specified under (i) above which will require more detailed data and information.

This study has demonstrated the usefulness of a farm household production model in understanding the decision process, farming household behavior and motivations, and their policy implications both at the farm (micro) and national (macro) levels.

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ACKNOWLEDGEMENTS

I would like first to thank my major professor, Dr. Raymond R. Beneke, for his helpful criticism and suggestions throughout this study and for his guidance during my M.S. graduate program.

I would also like to extend my appreciation to the other members of my graduate committee, Dr. Hylke Van de Wetering and Dr. Vincent Sposito, for their comments and suggestions.

Several people and agencies have made some significant contributions to the success of this study. In particular, the Planning Division, MAWD, for funding and allowing me to pursue my studies, Dr. Tesfaye Teklu for his encouraging suggestions and comments, and my parents for patience with my desire to pursue higher learning.

Finally, my appreciation goes to Diana McLaughlin for typing this report and in assistance in checking it for errors.