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An Optimization Analysis of Maize-Based Farming Systems in the Central Region of Ghana

by

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University of Ghana, Legon

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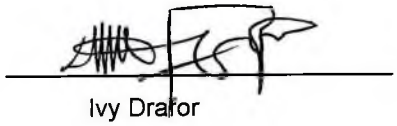
Declaration

I declare that this research was undertaken by me personally. The dissertation is my original work and has not been presented for any degree in this university or elsewhere.



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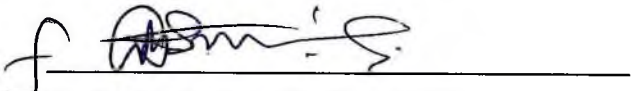

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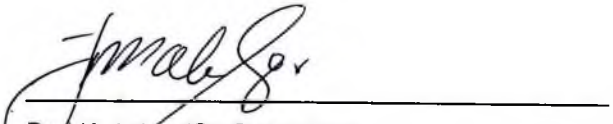

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Table of Contents

List of Tables v

List of Figures vi

Abstract vii

Acknowledgments ix

List of Acronyms xi

Chapter One: Background and Problem Statement 1
1.1 Introduction 1
1.2 Statement of the Problem 3
1.3 Purpose and Objectives 5
1.4 Importance of Study 7
1.5 Organization of Study 8

Chapter Two: Selected Issues in Agricultural Production 10
2.1 Introduction 10
2.2 Food Production in Ghana 10
2.2.1 Major Constraints in Food Production 11
2.2.2. Trends in Maize Production 12
2.3 Policy and Food Security 14
2.4 The Role of Gender in Food Production 18

Chapter Three: Literature Review 21
3.1 Introduction 21
3.2 Maize Farming Systems 21
3.3 The Role of Gender Analysis 23
3.4 Analysis of Food Security 24
3.4.1 Food Security and Poverty 27
3.5 Empirical Analysis for Farmer Decision Making 28
3.5.1 Relevance of Linear Programming Models 30
3.6 Empirical Analyses Using LP Models . . . 32
3.6.1 Linear Programming and Resource Allocation 35

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3.7 Summary of Literature Review 37

Chapter Four: The Survey and Survey Results 38
4.1 Introduction 38

A. The Survey 38
4.2 The Case Study Area 38
4.3 Methods of Data Collection 41
4.3.1 Sampling Procedure 41
4.3.2 The Survey Exercise 43
4.3.3 Description of Survey Data . . . 45

B. Survey Results 46
4.4 Farming Systems in the Central Region 47
4.4.1 Seasonality 49
4.4.2 The Importance of Maize to Farmers 50
4.4.3 Land and Land Tenure Systems 51
4.4.4 Fertilizer Usage 53
4.5 Major Problems Identified by Farmers 55
4.6 Demography and Social Status of Respondents 56
4.7 Gender Issues Among Respondents 58
4.8 Selection of Groups of Farmers. 63

Chapter Five: Method of Analysis 66
5.1 Chapter Overview 66
5.2 Theoretical Framework 66
5.3 Model Specification 68
5.4 The Gross Margin . . 72
5.4.1 Activities 73
5.5 Resource Endowment . . 76
5.6 Cropping Calendars . . 82
5.7 Crop Enterprise Budgets . . 82
5.8 Linear Programming Matrices . . 90
5.9 Scenarios for Simulation . . 92

Chapter Six: Optimization Analysis and Results 94
6.1 Introduction . . . 94
6.2 Base Scenarios 94
6.3 Linear Programming Results for Male and Female Farmers 95
6.3.1 Resource Use . . 98

University of Ghana http://ugspace.ug.edu.gh

6.3.2 Fertilizer Usage ... 101
6.3.3 Revenue Generated From Different Crops 102
6.3.4 Sources of Food for Consumption ... 105
6.4 Results Based on Whether or Not Farmer Participated In Agricultural Projects ... 106
6.4.1 Resource Use for Farmers With and Without Agricultural Assistance ... 108
6.4.2 Revenue Generated From Different Crops ... 111
6.4.3 Sources of Food For Consumption ... 113
6.5 Sensitivity Analysis ... 116
6.5.1 Increase Rented Land ... 117
6.5.2 Increase in Hired Labour ... 119
6.5.3 Increase in Credit Availability ... 120
6.5.4 Increase in Yield ... 120

Chapter Seven: Summary and Conclusion ... 123
7.1. Summary ... 123
7.2 Limitations of the Study ... 125
7.3 Major Findings and Conclusions ... 125
7.4 Policy Implications of Findings and Recommendations ... 129
7.5. Recommendations For Further Study ... 133

References ... 134

Appendix I: Interview Schedule: Interview Schedule for Maize Farmers ... 144

Appendix II: Cropping Calendars On Per Acre Basis ... 156

Appendix III: Crop Enterprise Budgets by Gender ... 162

Appendix IV: Crop Enterprise Budgets by Agricultural Assistance ... 169

Appendix V: Simulation Results ... 176

University of Ghana http://ugspace.ug.edu.gh

List of Tables

Table 2.1 Production and Yield Levels of Major Food Crops in Ghana (1992-1998) 12
Table 2.2 Expenditure Patterns By Income Class in Percentages - 1988/89 14
Table 4.1 Sample Distribution of Respondents by District and by Gender 43
Table 4.2 Types of Land Ownership in the Study Area 52
Table 4.3 Terms of Payment for Land Use in the Central Region of Ghana 53
Table 4.4 Crop Yields in the Study Area for Major Season of 1998* 55
Table 4.5 Problems of Mobilizing Labour 56
Table 4.6 Level of Education of Respondents 57
Table 4.7 Marital Status and Religion of Farmers in the Central Region of Ghana 58
Table 4.8 Access To Agricultural Assistance and Other Inputs by the Respondents Presented by Gender 62
Table 4.9 Characteristics of Farmers By Gender 63
Table 4.10 Characteristics of Farmers Who Participated in Agricultural Programmes and Non-Participants 63
Table 5.1 Male and Female Crop Enterprises and Their Abbreviation 74
Table 5.2 Cropping Enterprises, With and Without Agricultural Assistance 75
Table 5.3 Capital Distribution by Farmer Type 79
Table 5.4 Prices of Inputs Used by the Respondents 81
Table 5.5 Average Prices of Output of the Crops Under Consideration 84
Table 5.6 Gross Margin Calculations for Male Farmers 86
Table 5.7 Gross Margin Calculations for Female Farmers 87
Table 5.8 Gross Margin Calculations for Farmers With Agricultural Assistance 88
Table 5.9 Gross Margin Calculations for Farmers Without Agricultural Assistance 89
Table 5.10 Values of Consumption Requirements for Farm Households 92
Table 6.1 Scenarios in the Base Model 95
Table 6.2 Optimal Enterprises for Male Farmers 97
Table 6.3 Optimal Farm Plan for Female Farmers 97
Table 6.4 Land Use Patterns of Male and Female Farmers 99
Table 6.5 Capital Availability and Use for Male and Female Farmers 100
Table 6.6 Labour Use For Male Farmers 101
Table 6.7 Labour Use for Female Farmers 101
Table 6.8 Male Farmers' Revenue From Various Crops 103
Table 6.9 Female Farmers' Revenue From Various Crops 103
Table 6.10 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Male Farmers 104
Table 6.11 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Female Farmers 104
Table 6.12 Sources of Food and Consumption Patterns for Male Farmers 106

University of Ghana http://ugspace.ug.edu.gh

Table 6.13 Sources of Food and Consumption Patterns for Female Farmers .. 106
Table 6.14 Optimal Farm Plan for Agricultural Assistance Recipients 107
Table 6.15 Optimal Farm Plan for Farmers Without Any Assistance .. . 107
Table 6.16 Land Use for Farmers With and Without Assistance 109
Table 6.17 Capital Availability and Use for Farmers Without Agricultural Assistance 109
Table 6.18 Labour Use For Farmers With Agricultural Assistance .. 110
Table 6.19 Labour Use for Farmers Without Assistance .. 110
Table 6.20 Revenue From Various Crops for Farmers With Agricultural Assistance . .. 112
Table 6.21 Revenue From Various Crops for Farmers With No Assistance ... 112
Table 6.22 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Farmers with Agricultural Assistance 113
Table 6.23 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Farmers Without Agricultural Assistance . . . 113
Table 6.24 Sources of Food and Consumption Patterns for Farmers with Agricultural Assistance 115
Table 6.25 Sources of Food and Consumption Patterns for Farmers Without Agricultural Assistance 115
Table 6.26 Parameters from All Base Scenarios of the Linear Programming Model 116
Table 6.27 Summary of Scenarios for Simulation .. 117
Table 6.28 Effect of Increasing Rented Land for Female Farmers 118
Table 6.29 Effect of Increasing Rented Land for Farmers Without Assistance 119
Table 6.30 Changes in the Income Level with Varying Parameters 121

List of Figures

Figure 2.1 Trends of Fertilizer Prices from 1983 to 1998 17
Figure 4.1 The Map of Ghana Showing the Central Region 40
Figure 4.2. Sample Distribution of the Respondents by Gender 42
Figure 4.3 Food Crop Farm Sizes of Respondents by Gender (1998) 58
Figure 4.4 Maize Harvest by Gender 60

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Abstract

Maize, the most important cereal in Ghana, is consumed in almost all parts of the country. To ensure food security in Ghana, adequate availability of maize must be ensured. However, whether or not farmers should devote their resources to the production of more maize is a question to be addressed. Since food security has more to do with availability than with production or self-sufficiency in the product, it was necessary to investigate whether it is better for farmers to grow what they consume or to purchase their food needs. As women have been found to produce the bulk of the food consumed in Ghana and a gender-differential analysis is relevant.

This study determines the relative profitability of different crop enterprises, using the Central Region of Ghana as a case study. A linear programming model was employed to determine the optimal farm plan, and the revenue generated from the different crops if farmers adopted the optimal farm plan were calculated. Seven farmers were interviewed in each of 15 villages in three districts in the region (5 villages per district). The data was used to prepare crop enterprise budgets and cropping calendars, which were used to build the linear programming matrices. Two categories of farmers were used in the investigation, categories differentiated by gender and by participation in agricultural programmes. The farm enterprises of male and female farmers were analysed separately to see if there were differences in their performance, and a similar analysis was undertaken for farmers who participated in agricultural programmes and those who did not.

The results of the survey show that women devote a greater proportion of their farm output to household food consumption than their male counterparts. Female farmers were also more resource constrained than male farmers. Participation in agricultural programmes was found to have a strong influence on the use of modern techniques of farming, hence, on farm productivity. However, only 17 percent of the female farmers interviewed participated in agricultural programmes while 42 percent of the male farmers

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participated in such programmes, which is a form of assistance, mostly from NGOs. Financial constraints were the topmost problem expressed by the farmers. The farmers consider maize as a main crop that assures them of food availability and gives them a sense of food security. No crop was found to be a 'female' crop, and types of crops grown were common to male and female farmers, but types of crop enterprises varied slightly with participation in agricultural programmes. Those who participated in agricultural programmes had enterprises with fewer crop combinations.

The data was then used to build a linear programming model for each farmer group under consideration. Four base scenarios were run and the value of the objective function was highest for male farmers, followed by that of farmers who participated in agricultural programmes and that of female farmers was lowest. The linear programming analysis showed that all the categories of farmers considered preferred to produce what they consume. Maize was found to be the second highest in revenue generation for the farmer using the optimal plan. Vegetables, especially garden-eggs (or egg plant) was highest in revenue generation. The productivity of land appeared higher for female farmers than for male farmers as it recorded a very high shadow value. A sensitivity analysis was conducted and an increase in yield produced the highest increase in the value of the objective function for all farmer groups.

It is recommended from the study that a system should be put in place to ensure that farmer selection for agricultural programmes are gender sensitive for increased participation of women farmers. Bottlenecks in credit acquisition should be removed for a better access to credit. However, land reforms are needed at the local level because giving female farmers credit without an improvement in their access to land will not benefit them. Selective subsidies on inputs such as fertilizer for small-scale farmers need to be considered by the government. Finally, resources could be devoted to an increased production of maize as maize generates a good revenue for the farmer if prices are favourable.

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List of Acronyms

ADRA	Adventist Development and Relief Agency
ARME	Department of Agricultural Resource, Management and Economics, Cornell University.
CEDECOM	Central Development Commission
CIIFAD	Cornell International Institute of Food and Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CRI	Crop Research Institute
FAO	Food and Agricultural Organization of the United Nations
GAP	Greater Afram Plains
GDP	Gross Domestic Product
GLSS	Ghana Living Standards Survey
GNP	Gross National Product
IFPRI	International Food Policy Research Institute
ISSER	Institute of statistical Social and Economic Research of the University of Ghana, Legon, Accra
MOFA	Ministry of Food and Agriculture
NARP	National Agricultural Research Project
NGO	Non-Governmental Organization
PPMED	Policy Planning, Monitoring and Evaluation Directorate
SAP	Structural Adjustment Programme
SG2000	Sasakawa Global 2000
WIAD	Women in Agricultural Development
¢	Represents the sign of the cedi, the Ghanaian currency. The exchange rate at the time of data collection was 2500 cedis to one US dollar.

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Chapter One

Background and Problem Statement

1.1 Introduction

More than 800 million people in the developing world do not have access to sufficient food to meet their needs for a healthy and productive life. Access to food by individuals is conditional on the level of poverty (World Bank, 1992). Despite production of enough food to feed the world, almost one-fifth of the total population of developing countries goes hungry. Availability of enough food at global, national and regional levels does not mean it is evenly distributed and that everyone is well-fed (Pinstrup-Andersen, 1994). Each nation, community and household has the responsibility of providing enough food for its people, whether through production or purchase.

Under Ghana's Vision 2020 programme, which aims at transforming the nation from a low-income country into a middle-income country by the year 2020, agricultural production is to grow at an annual rate of at least 8%. In the Vision statement, the agricultural sector is to ensure food security and adequate nutrition for all Ghanaians, supply raw materials and inputs to other sectors of the economy, contribute to the improvement of the balance of payment situation, and provide producers with farm incomes comparable to earnings outside agriculture (MOFA, 1997).

Maize is Ghana's most important cereal crop and is a major staple food in most parts of the country. The Policy, Planning, Monitoring and Evaluation Directorate (PPMED) of the Ministry of Food and Agriculture estimates that maize is grown on about 665,000 hectares, with about 1 million metric tons of output produced annually (ISSER, 1996). Maize is used in the preparation of *banku, akple, kenkey*, porridge, and other meals. Land area allocated to maize production as a percentage of total cereal area is about 52 percent, according to an International Maize and Wheat Improvement Center (CIMMYT)

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report. About 79 percent of the maize produced in Ghana is used for direct human consumption with only 6 percent being used as animal feed (CIMMYT, 1993/94). The remaining 15 percent can be attributed to cross border trade in maize with neighbouring countries such as Togo, Burkina Faso and Mali, which is largely not recorded. Maize is moved across the border just after harvest to these countries. It is believed that some of these traders store some of the maize and resell it into Ghana during shortage periods.

Most of the maize consumed is produced by women farmers who have the dual responsibility for food production and household duties. Most of these women farmers are among the rural poor. Bortei-Doku (1990) observed that women are responsible for as much as 80 percent of food production in Ghana. The FAO records that women produce between 60 to 80 percent of the food in most Sub-Saharan African countries and are responsible for half of the world's food production, and their key role as food producers and providers need to be improved (FAO, 1998).

These women farmers face significant barriers in performing their roles in growing food crops. A major constraint faced by these women is limited or no access to productive resources such as land, credit and adequate extension services. Besides, information on women farmers and the farms they manage is limited even in the developed countries such as the USA, and thus, little is known about how women manage farms (Zeuli and King, 1998). Organizations that seek to reach them in Ghana such as Women in Agricultural Development and various NGOs are typically unable to reach them effectively due to lack of resources and personnel. An IFPRI news release stated that failure to remove these barriers could severely compromise food security, health care, and nutrition in the coming years (IFPRI, 1995).

The demand for maize as food and feed is expected to increase, especially in developing countries, with an increase in demand projected at 4.1 percent per annum and 3.2 percent per annum in Sub-Saharan Africa up to the year 2000 and beyond (Byerlee

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and Saade, 1993). While per capita food production is increasing in developed countries, it is on the decline in Sub-Saharan Africa, due to the increase in the rate of growth in population which is in excess of food production growth rates. The World Bank reports the population of Ghana to be 17.5 million in 1996, and the FAO states that it is growing at a rate of about 3.2 percent per annum (World Bank, 1998; FAO diskette of population statistics, 1993). However, agricultural production has only been growing at the rate of 2.5 percent. Population increases force farmers to occupy fragmented and less productive lands leading to a drop in per capita yields, with adverse effects on the income level and food situation of the farmer and the nation as a whole. Savadogo, Reardon and Pietola (1994) asserted that Africa is the only developing region where crop output and yield growth is lagging seriously behind population growth.

With rapid growth in population and increasing demand for maize, policies that will generate increases in food production and availability will need to be put in place. Furthermore, the effectiveness of existing policies in achieving their desired objectives should be thoroughly examined and revisited on a continuous basis. It is critical to pay close attention to rural development in Ghana as over 60 percent of the population live in rural areas and contribute about half of the nation's GDP annually. As emphasized by ISSER (1999), agriculture remains the main contributor to GDP, followed by the services sector and then the industrial sector.

1.2 Statement of the Problem

With population of Ghana increasing at 3.2 percent per year, agricultural production growing at 2.5 percent annually, and demand for maize as food projected to grow at 3.2 percent (the same rate at which population is growing), there arises the problem of maize availability. Since maize production is not keeping pace with the growth in population, it is necessary to (i) find out why farmers are not readily directing their resources to increase

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maize production, (ii) investigate whether or not it is profitable to expand the maize production base for home consumption and for sale, or purchase the maize necessary to meet food security needs.

Tibaijuka (1994) stated that, "beyond family subsistence, there must be incentives for further production" Maize production cannot be increased if the maize producer does not have a strong enough incentive to expand the production base (in terms of both area allocated to maize and increase in cash investment in the maize enterprise). There exists no stronger incentive than clear evidence of an increase in the net income of the farmer as a result of the maize enterprise(s). Therefore, comparing the performance of each food enterprise becomes necessary, which is a major goal of this research.

Maize farmers in Ghana play a major role in ensuring food security in the nation. However, the factors that affect their income, which determines their living standards, are not often well understood by policy makers and this is reflected in their policy formulation. The problems of poverty and food insecurity will continue to persist until an analysis of the profitability of their different enterprises is undertaken to enable policy makers to design cost-effective alternatives for farmers, taking their resource endowments and other constraints into consideration.

Devoting more resources to the production of more maize at relatively stable prices could be the turning point in the fight against poverty and food insufficiency, because the food situation in Ghana is often expressed in terms of the availability and price of maize. Furthermore, shifting resources from other sectors into domestic food production would enhance growth and development. Enhancing food security is not likely without a significant shift in the maize supply. The Ghana Living Standards Survey (GLSS) showed that agriculture is the most important source of income in Ghana, accounting for about 56% of the total income of the population (GLSS, 1989).

As much as population control measures are needed, improved methods of farming

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ought to be adopted and farm inputs need to be made available to farmers at affordable prices if production is to keep pace with the increase in population and the increased demand for maize. Many farmers, especially in the small and medium-scale categories are net-food buyers (Elabor-Idemudia, 1991; Singh, Squire, and Strauss, 1986). Thus, they produce farm products for both consumption and sale, but re-enter the market to buy food (the same type they produce) when their stock is exhausted. According to Singh, Squire, and Strauss (1986), behavioural patterns characteristic of these semi-commercial producers are complex, making it difficult for policy makers to predict the consequences of policies on them and to expressly determine their responses to various policies. As such, the option of producing other crops and purchasing the maize required for the home need to be evaluated.

The net income of the subsistence farmer has remained an issue of great concern to both national and international policy makers for several years. The vision that emerged in the early 1960s as a guide to the sources of growth in agricultural production included a more positive view of the role of peasant producers in the process of agricultural development (Ruttan, 1994). Little has been done, however, to improve the productivity of the main food crops or to generate dynamic innovation in the small farm sector (World Bank, 1995a).

1.3 Purpose and Objectives

The purpose of this research is to study the productivity of food crop enterprises, determine the relative profitability of different crops in maize-based farming systems, and to undertake an optimization analysis using the Central Region of Ghana as a case study. The results of the quantitative analysis will further explain and supplement a qualitative analysis of the maize-based farming systems. The main research is to find out whether it is profitable for farmers to allocate more resources to maize-based production. The

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analysis will show whether gender and participation in agricultural programmes play an important role in the performance of farm enterprises.

Allocating more resources to maize production will lead to an improved food security situation as well as help alleviate poverty. To promote an increase in maize production, the farmer needs a strong enough incentive to enable him/her to allocate more resources to maize production, considering the relative performance of the other food crop enterprises. Furthermore, development assistance must be linked with farmer decision making, or else the impact cannot be what is desired.

The objectives of the study are therefore as follows:

a. To analyze the socio-economic characteristics of maize-based farming systems in the Central Region of Ghana. Under this are the following sub-objectives:
   i. Categorize the farmers into groups by homogeneous characteristics such as gender, age, farm size and educational background.
   ii. Determine the cropping patterns characteristic of the farming systems in the Central Region.

b. To analyze and compare the performance of crop enterprises by gender and participation in agricultural programmes, based on the different resource endowments of the farmer groups.

c. To examine the constraints on food production in the Central Region of Ghana.

d. To determine optimal enterprise combinations and activities that maximize net returns for four farmer groups, using farm-level linear programming analysis.

e. To carry out a policy analysis using simulation, assessing the implications of present policy on food security and to make recommendations towards improving the state of food security. This involves the following;
   i. Assessing the prevailing government policies that either directly or indirectly affect food security and their impacts on maize-based farming systems and

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the implications for food security.

ii. Undertaking a simulation analysis of the impacts of some of the current policies.

iii. Making policy recommendations about maize production and suggesting strategies for improving maize availability in Ghana.

1.4 Importance of Study

A programme which increases agricultural production will almost certainly have a direct impact on rural welfare by simultaneously increasing the availability of food and farmers' incomes (Mellor, 1966). Most policy makers are concerned about the income of the farmer. Getting the income of the farmer to increase will promote rural development in less developed countries. Many studies have considered the effects of policy on the subsistence farmer but they have not undertaken an optimization analysis of maize-based farming systems in the major production areas of the country. To assess the standard of living of the farmer, an important step is to analyse the resource availability and utilization levels, the productivity of their resources, and the net returns from their farm enterprises.

Furthermore, a gender differential analysis reveals possible disparities within the household and draws the attention of policy makers to addressing such needs. Research work providing practical recommendation for enhancing farm incomes, especially the incomes of women food producers, is highly limited. Farmers need to be presented with information that could assist them to make more informed choices. The neglect in viewing women farmers as the major food producers and including them in all developmental projects is detrimental to the state of food security in Ghana, especially in the face of a fast growing population.

Traditional research usually provides recommendations for policy without results from a micro-level analysis using farmer-specific data, which forms the basis of a farmer

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decision-making process; one that can present farmers with informed outcomes of each choice. The findings of this study will be relevant to the farmer's circumstances, and will provide policy recommendations that assist policy makers, including the government, non-governmental organizations and major donors in policy formulation. Farmers can readily see the best or optimal combinations of enterprises, the optimum levels of resources required for each choice made and the consequences of a small change in parameters such as land and credit. Agricultural extension workers will be able to use the results to hold well-informed discussion sessions with farmers that will assist them on improving their farm enterprises, as well as addressing the specific needs of women farmers who are not adequately reached.

An optimization analysis has not been done in the Central Region using cross-section data. Aggregate data is limited to few composite product categories because of lack of more detailed data on labour, land, and capital allocation over crops (Savadogo, Reardon and Pietola, 1994). Research into the productivity of resources and their optimal levels will provide recommendations for policy on food security and poverty reduction. The study can be extended further to cover the whole nation, serving as a basis for developing strategies for enhancing national food security.

1.5 Organization of Study

The study is divided into seven chapters. Chapter One is the introduction with the following sub-sections: background information, statement of the problem, purpose and objectives, importance of the study and the organisation of the study. Chapter Two further explains the issues of the problem in much detail. It discusses the poverty situation in Ghana as it relates to food security, farming systems, problems of food production, the role of women farmers in household food security and the effects of government policy on farmers.

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The third chapter is the review of the relevant literature on the subject. Empirical analysis using linear programming and other methods of analysis were reviewed with the view of selecting the most appropriate model to achieve the objectives of the study. Chapter Four gives a detailed description of the farmer survey and survey results. A detailed description of the data and its sources, data collection methods used, sample and sampling method, and the estimation procedure for the descriptive statistics are presented in this chapter.

Chapter Five describes the methodology for the study. The theoretical framework for the analysis is first provided, followed by an outline of the model. Scenarios for the simulation are then introduced and explained. Chapter Six presents the linear programming analysis, its results, and the results for the simulation analysis. Chapter Seven is the summary and conclusions of the study. The chapter also presents policy implications and recommendations stemming from this study.

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Chapter Two
Selected Issues in Agricultural Production

2.1 Introduction

This chapter discusses agricultural production in Ghana and its effect on food security. The case of inadequate maize production is discussed in the context of policy and food security. Further, the role of gender in food production is discussed. The discussions provide more insight into the problem being addressed in this study.

2.2 Food Production in Ghana

Problems of food insecurity and food availability continue to persist in Ghana. The structural adjustment programme (SAP) was designed to halt the economic decline of the Ghanaian economy and was launched in 1983. Two of its objectives were to boost production levels and promote exports in order to increase foreign exchange reserves. The SAP recorded some successes but led to a relative neglect of the food sector of the economy and the budget allocated to the development of the food production sector declined considerably. Sarris (1992) affirmed in his study that, regardless of Ghana's recent strides in terms of restoring growth and reforming economic policies, poverty and food insecurity remain serious problems that demand the attention of policy-makers searching for cost-effective interventions. An ISSER report stated that production of sufficient cereals for home consumption remains a major national concern in Ghana (ISSER, 1997). The effectiveness of policy intervention programmes in achieving their desired objectives needs to be thoroughly examined and revisited.

Consumers are also affected directly by instability in agricultural production through its effect on the availability and price of food (Smith, 1997). These impacts, he said, are most severe in low income countries where a large proportion of income is spent on food.

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Consumers' real incomes change dramatically with unpredictable changes in the prices of food.

2.2.1 *Major Constraints in Food Production*

Farmers in Ghana are highly constrained by a number of factors. They have limited land holdings which make it difficult for them to increase the acreage of production when they have the incentive to do so. Most of the farms are fragmented and scattered at different locations. Mechanization is limited, partly due to size and unfavourable topography of some farms. As a result, farmers usually have very low incomes and are not creditworthy as they lack the kinds of collateral security demanded by the banks to obtain credit. They therefore use little or no purchased inputs. Little labour is hired and the use of agro-chemicals is limited. Above all, these farmers produce on a semi-commercial basis. That is to say, they produce for both home consumption and for sale, but re-enter the market to purchase food when their supply is finished; they are net food buyers.

Another problem is the availability and accessibility of inputs coupled with the problem of timeliness of supply as most of the inputs arrive when the season is over. The SAP's subsidy removal policy has caused the price of inputs to increase considerably. According to Ndayisenga and Schuh (1997), the main focus of government policies should be on ensuring that chemical fertilizers are affordable and profitable. For example, in the United States, Knutson, Taylor, Penson and Smith (1990) estimated that outright ban on the use of inorganic fertilizer would result in an increase in cultivated acreage, rise in soil erosion, and a 14.2 percent increase in food expenditure per household per year.

Recurring droughts, pests and diseases, coupled with post-harvest losses have resulted in total loss of output for farmers. Poor rural infrastructure contributes to further losses as the produce cannot be transported to marketing centres promptly for sale. Besides, due to lack of appropriate technology and low use of inputs, yields are often low

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and farmers income continue to be low. Emphasis on cash crop production has resulted in the use of most fertile lands in the production of export crops.

For farmers to become better off in society, they must be able to cope with the increases in prices of goods and services and the effects of persistent devaluation of the currency. The farmer needs to produce at a profit in order to purchase the highly priced inputs from which subsidies have been removed.

2.2.2. *Trends in Maize Production*

Table 2.1 presents the output and yield levels of maize, cassava, plantain and cocoyam from 1992 to 1998. Yields have remained relatively the same since 1993 for all the crops presented in the table. Output of maize is below the 1995 levels, while population and maize demand continue to increase annually, presenting the nation with decreasing per capita production.

Table 2.1 Production and Yield Levels of Major Food Crops in Ghana (1992-1998)

Year	Maize		Cassava		Plantain		Cocoyam	
	Output '000 Mt.	Yield Mt/Ha	Output '000 Mt.	Yield Mt/Ha	Output '000 Mt.	Yield Mt/Ha	Output '000 Mt.	Yield Mt/Ha
1992	731	1.2	5662	10.3	1080	6.9	1202	6.1
1993	961	1.5	5973	11.2	1322	8.1	1236	7.1
1994	940	1.5	6025	11.6	1475	8	1148	6.4
1995	1034	1.6	6612	12	1638	7.7	1383	6.9
1996	1008	1.5	7111	12	1823	9	1552	7.3
1997	996	1.5	7000	11.9	1818	8.1	1530	7.4
1998	1015	1.5	7172	11.4	1913	7.8	1577	7.2

Source: PPMED of Ministry of Food and Agriculture, 1998

Maize producers face very high post-harvest losses, especially in Larger-Grain Borer infested areas where losses are estimated to be about 30 to 40 percent of all

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harvested maize every year (Ghana Statistical Service, 1995). This situation also adds to the problem of insufficient maize supply. Furthermore, maize prices have high seasonal variability with very low prices at harvest time and very high prices between planting and harvest period of the major season. Stability of prices would reduce the incidence of selling maize at very low prices just after harvest due to financial constraints and lack of storage facilities, as well as serve as an incentive for increased production.

Production instability creates uncertainty and results in the reduction of investment in physical and human capital that could potentially raise agricultural productivity. Price instability also goes to dampen the potential investment by the private sector in assisting farmers, and in off-farm marketing and processing activities (Smith, 1997). Lack of a steady growth in production coupled with production instability affect per capita output because population continues to increase.

As mentioned earlier, due to the semi-commercial behaviour of these farmers, high prices do not only affect consumers in the urban areas but maize producers as well. Women farmers are particularly affected adversely as they attempt to ensure that there is sufficient food for the household. After purchasing food, the farmers are left with very little income for purchasing other goods and services and for acquisition of inputs for the next season. This strategy of ensuring household food security deprives them of the freedom of a wide range of choice and self-esteem, and they remain in a vicious cycle of poverty.

Kraus (1991) estimated that Ghanaians spend an average of 69 percent of their incomes on food. Therefore, food prices are one of the most important determinants of standard of living. Table 2.2 presents the expenditure patterns of Ghanaians in 1988/89. Most of the income is spent on home food and food bought. The poor and the moderate poor spend a very small percentage of their income on home non-food and other expenses. As observed by Kraus, relative neglect of food production and high food prices had earlier been an increasing source of popular opposition to the government (Kraus,

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1991). High food prices also result in widespread malnutrition, which affects the diets of the people; and diet affects health directly.

Table 2.2 Expenditure Patterns By Income Class in Percentages - 1988/89

Class	Home Food	Home Non-Food	Food Bought	Non-Food Bought	Other Expenses
Extreme Poor	32	3	35	23	7
Moderate Poor	28	4	37	23	8
Non-Poor	17	8	40	26	10
Rich	7	15	37	27	14

Source: Seini, Nyanteng, and Van den Boom, 1997

The main nutritional deficiencies affecting populations in developing countries include the controversial but real protein-calorie deficiency, anaemia, goiter, and vitamin-A deficiency (Bressani and Elias, 1979). An increase in maize production is a main concern if the food and nutrition situation in the nation is to be improved and the standard of living of the rural community is to change. Maize production needs to increase both for food and feed to improve nutrition security. The cost of the main sources of protein such as meat, chicken and fish is very high and an adequate quantity of these is not affordable to the average Ghanaian. Maize is used as an animal feed, especially for poultry and can form a major part of the cost of production. For large families, which are rather common in Ghana, the consumption of meat and chicken is reserved for special occasions such as Christmas. An increase in the production of maize and other cereals for feed will lead to a reduction in the cost of feed, making meat relatively cheaper and more affordable to the majority of the people.

2.3 Policy and Food Security

Good economics and good policies go together. Good public policies for poverty reduction [and improvement of food security] will never be implemented until those who

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must carry out these policies have the motivation and incentive to do so (World Bank, 1997).

As noted earlier, Africa is the only developing region where crop output and yield growth is lagging seriously behind population growth despite the vital role of agriculture in its economic development (Savadogo, Reardon and Pietola, 1994). James (1995) observed that the development planners in Africa have often neglected the most crucial aspect of development, which is agriculture. Tsakok (1990) added that it becomes clear that a weak agriculture cannot support a strong industry, and many governments have had to reassess their entire development strategy, emphasizing that in many countries problems in the agricultural sector have spilled over into the rest of the economy and have contributed to crisis in industry, the trade balance, and the government budget.

Poverty alleviation policies and programmes should therefore be targeted towards small farmers (Asenso-Okyere, Asante and Gyekye, 1993). Poverty alleviation is essential, for poverty ruins lives and undermines development, the environment, and political stability. As mentioned earlier, poverty in Ghana is largely a rural phenomenon with about 65 percent of the population living in rural areas and about 27 percent living in urban areas, excluding Accra (Boateng, Ewusi, Kanbur, Mckay, 1990). Agriculture provides about 50% of GDP and more than 90 % of this production occurs in the traditional sector where the average holding is less than 1.6 hectares (Dowswell, Paliwal, and Cantrell, 1996). The heads of most poor households are self employed, poorly educated and own no cocoa land. Development programmes continue to ignore them as a result of the design and the criteria for farmer selection. James (1995) said:

> History informs us that the successful societies that are well-planned and manage their development processes well have been able to do so because of sustained food supply. The more successful societies become agriculturally, the more they can devote more time and energy to planning their neighbourhoods and communities.

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Farmers in Ghana invariably have very little direct government support after the Economic Recovery Programme and the SAP. With the launching of the SAP, the role of the government was to minimize its direct participation in the economy through rapid market liberalization, and to increase the role of the private sector. According to Smith (1997), where the private sector is not fully developed, public sector agencies can play an important role in performing or financing stabilization services. Though a minimal role of the government may be desired, it is clear that government's role cannot be wholly passive. The private sector needs to be built up over time to take over the government roles.

The Ministry of Food and Agriculture provides some services to small holder farmers and farming communities through donor-funded projects with the objective of alleviating poverty in the rural areas (ISSER, 1996). The coverage and sustainability of these projects need to be questioned. It is found that African countries, such as Nigeria, which discovered mineral resources in the past 20 years, have neglected the agricultural sector of the economy (James, 1995). In Ghana, the food sector has been neglected so as to promote export crops and mining of gold and other minerals. After the SAP, the budget allocation to the agric-food sector was reduced considerably.

The structural adjustment programme led to the removal of input subsidies and subsidies on medical services. Farm inputs (such as fertilizer) have become very expensive and many farmers who once used fertilizers have stopped using them. Figure 2.1shows the trends in the prices of NPK 15-15-15 and ammonium sulphate from 1983 to 1998. As mentioned earlier, high population growth rates have resulted in overtasking the land, thereby reducing the fertility of the soil. Increases in the production of maize of late have been attributed to the use of inorganic fertilizer, though its continual use is an issue of debate. The poor financial state of the rural food producers makes it impossible for them to purchase fertilizers, resulting in low output levels. According to Heisey and Mwangi (1997), a strategy that seeks to meet Africa's future food needs will have to feature the use

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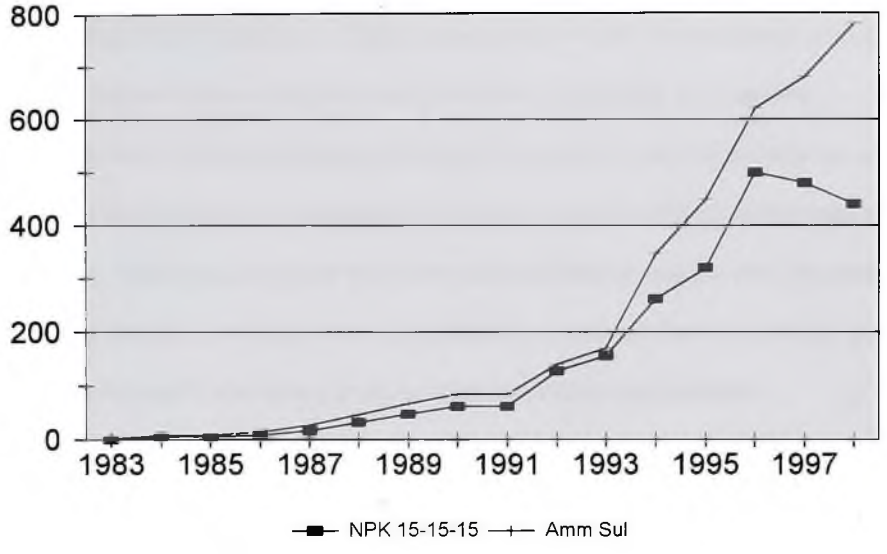
of mineral fertilizer.

Figure 2.1 Trends of Fertilizer Prices from 1983 to 1998



Source: ISSER, 1998

From another perspective, the fact that most farmers cannot afford fertilizer results in low yields, and these low yields mean low income. The situation further makes it almost impossible for them to purchase enough food in times of scarcity (when their stock is finished or when they do not grow what they consume). The question policy makers have been attempting to answer is whether or not to reintroduce subsidies on fertilizer, and if so, is it economically recommended to do so?

The Ghana Government and World Bank policies can easily exclude the rural poor, especially women, from the development plans and processes. According to the World Bank, food poverty is more prevalent in the rural than urban areas, and poverty is linked with average family size and dependency ratios, which are higher in rural than in urban

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areas (World Bank, 1997b). While farmers in Ghana have little or no assistance to provide all the agricultural products needed for food, to feed livestock, to feed agro-based industries and meet export requirements, many industrialized countries provide significant support to their agricultural producers. Examples are the EU Common Agricultural Policy, and the US Farm Bill. Gardener, (1992) reported that in the United States farm sector, government intervention over most of the 20th century has been far-reaching.

There is an increasing awareness of the implications of leaving out women and the poor from development plans. According to Pinstrup-Andersen (1994), hunger associated with failure to effectively integrate the poor and vulnerable groups into the economic development process is evident and will accelerate unless policies to alleviate poverty, generate employment, and raise [rural] incomes are vigorously pursued.

2.4 The Role of Gender in Food Production

It has been noted that women produce between 60 and 80 percent of the food in most developing countries and are responsible for half of the world's food production (Saito, 1994; FAO Website 1998). Yet their role as food producers and providers, and their critical contribution to household food security, is often not recognised. The FAO and other studies such as Saito (1994) confirm that women have more difficulties than men in gaining access to resources such as land, credit and productivity-enhancing inputs and services. According to Saito, the productivity of African women farmers is well below its potential, arguing that women would be more productive if given the same resource endowments like their male counterparts. Tibaijuka observed that in economic activities, the gender division of labour shows that women have a greater labour input than men in Tanzania (Tibaijuka, 1984).

In Ghana, women are involved in farm activities as well as all household activities which include food preparation, cleaning, caring for the children, fetching of water and

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firewood, and they sometimes have to prepare water for their husbands for bathing. Traditionally, men are not expected to involve themselves in much of household work, especially in the rural areas. Hence, men come home from the farm and sit to wait for the food to be served and water made ready for bathing while they listen to the radio and afterwards retire for sleep.

Women farmers are faced with limited resources, have small land holdings, limited or no credit facilities, use little or no agro-chemicals, and use the most traditional methods of farming. Land ownership by women farmers is still limited and highly restricted to user rights. Land reform programmes are continually desired by women farmers as they hardly own land or inherit land. This limits land improvement for higher productivity. They are also the most constrained in terms of their access to farm inputs, adequate extension services, and their participation in agricultural development projects such as those being carried out by SG2000 and ADRA is limited. Agricultural extension agents are usually men and do not fully understand female production problems nor are trained to reach them effectively. These and other constraints faced by women farmers lead to low yields and low total output, most of which is consumed in the home and they have little surplus to sell to meet other financial obligations.

Agricultural extension agents have in 1996-1998 been promoting the cultivation of export crops such as cashew, acacia and black pepper to enable farmers earn additional income. With the small land holdings of the small to medium-scale farmer, especially women, it could have implications for food security as it will be difficult for them to grow these crops and still have enough land to grow food to meet household needs. As such, these programmes will continue to benefit men, who have more secure land titles and larger land holdings. As long as the land ownership situation remains the same, women will continue to be disadvantaged.

Food crops such as cocoyam and vegetables are considered by some as 'female

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crops' and are enjoyed by both rural and urban consumers. There are no imported food products that can serve as close substitutes for many of the foods produced locally. There has, however, been very little agricultural research and extension work on these crops.

There are some organizations that work mostly with women such as the department of Women in Agricultural Development (WIAD) of the Ministry of Food and Agriculture. In the Central Region of Ghana, they engage in training agricultural extension frontline staff (now referred to as agricultural extension agents) in assisting farm families improve their standard of living (WIAD, 1995). Their work is now very limited with the decentralization in the Ministry of Food and Agriculture which occurred in 1997 and there is hardly any budget for their activities. The state of food security would be greatly enhanced if women were encouraged and assisted to improve their food crop enterprises. The neglect of women farmers in policy making directly affects the food security situation in the country.

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Chapter Three

Literature Review

3.1 Introduction

Qualitative as well as quantitative issues relating to the purpose of the study are reviewed in this chapter. The analysis of food security, and food security in relation to poverty, farming systems research, and gender analysis in food production are discussed before embarking on a review of the literature aiming towards the selection of a model for the study.

There is an extensive literature on linear programming (LP) models that are applied to different situations. A number of these models are reviewed in agricultural and non-agricultural situations to establish the basis for the choice and use of this approach in this research. The limitations of econometric techniques, gross margin analysis, and whole farm budgeting in achieving the objectives of the study are discussed as they do not permit multi-crop enterprise analysis. The results obtained by different researchers who employed linear programming are reported to serve as a basis for comparison with the results of this research.

3.2 Maize Farming Systems

Extension agents have experienced difficulty in understanding and promoting recommendations that address the problems of complex farming systems (Low, Senbert and Waterworth,1991). The selection of farming systems for an area is determined by the ecological environment. This includes the suitability of the environment to crops and livestock and the socio-economic environment such as farmer preferences, access to markets and production technologies (Diehl, 1992).

Maize has a great potential in Africa's lowland savanna and mid- to high altitudes

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and is expected to contribute importantly to meeting Africa's future demand for food (Dowswell, Paliwal and Cantrell, 1996; Byerlee and Heisey, 1992) Maize is grown principally for food in Ghana. Its use in animal feed is growing but limited to the poultry industry (Sallah, 1992). Variations in the output of cereals will alter the profitability of intensive livestock production through the resulting high feed costs. Byerlee and Heisey (1992) observed that where food production has been increased in Africa, it has mainly resulted from the adoption of improved maize seed. Increase in maize production has also been at the expense of increased use of land and labour resources. Sallah (1992) reported that the maize improvement programme at the Crop Research Institute (CRI) at Kumasi, Ghana, aims at developing improved varieties as its contribution towards increasing maize production to a level of self-sufficiency.

Many researchers have observed that maize is usually grown in intercropping systems in most parts of Africa (see for example, Sallah, 1992; Dittoh and Ogunforawa, 1987; Dowswell, Paliwal and Cantrell, 1996). Dowswell, Paliwal and Cantrell (1996) observed that most maize is intercropped primarily with cassava or cocoyam in southern Ghana or with sorghum, millet, or groundnuts in the northern parts of Ghana. Maize is also largely intercropped with plantain in the forest zones of Ghana.

The need to improve productivity in agriculture is unquestioned, in light of the stagnant yields in Sub-Saharan Africa compared to other regions (World Bank, 1997). The FAO indicates that the 'introduction of existing labour-saving technologies, improved seeds and fertilizers and simple agronomic practices, such as timely planting and weeding could lead to yield increases of 50% or more' (FAO, 1979). The challenge for policy makers is to promote the production of a marketable surplus of food by rural farmers. When this happens, the farmers will have enough to eat and their limited income will not be used to purchase food products which they themselves grow. There is a need to find ways of improving the farm enterprise without heavy dependence on foreign assistance.

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3.3 The Role of Gender Analysis

The importance of gender relations for food security has been raised and analysed by many researchers including Agarwal (1990), Alderman, Chiappori, Haddad, Hodinott, and Kanbur (1990), and Lundberg and Pollak (1996). Government programmes that direct resources and employment at male household heads assume implicitly that the associated benefits will be shared equitably with women and children (Agarwal, 1990). This approach assumes the unitary view of Samuelson (thus, the family is seen as one unit that shares common resources and makes decisions together) which is being criticized to incorporate the collective bargaining models that seek to include intra-household relations and their effect on food consumption patterns. Agricultural assistance (from government, NGOs and other donor organizations) is not usually directed to women farmers in Ghana.

The FAO defined gender as the central organizing principle of societies that often governs the processes of production and reproduction, consumption and distribution. Gender roles, they said, are the 'social definition' of women and men, and vary among different societies and cultures, classes and ages, and during different periods in history (FAO, 1997). Gender analysis represents a useful advance on previous attempts to conceptualize the social and economic lives of rural peoples in Africa. However, the complexity of the characteristics of different categories of women need to be taken into consideration (Warner, Al-Hassan and Kydd, 1997). Gender analysis seeks answers to fundamental questions such as who does or uses what, how and why, and to better understand the gender factors and realities within them (FAO, 1997).

Understanding the complex roles women play in the household and in the production unit is critical (Schuh, 1997; Warner, Al-Hassan and Kydd, 1997). It is crucial for the IMF and other international organizations to engage in consultations with a broad and good representative cross-section of the public of member countries, incorporating the poor and vulnerable (Culpeper, 1999).

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A study of rice farmers in Cote d'Ivoire revealed that women are at a disadvantage in their access to credit services, receive less for their output, and paid more for their chemical fertilizer than men (Adesina and Djato, 1994). Women are found to have lower yields than men, and the difference is attributed to the fact that women have less adequate access to credit and essential inputs and education (Adesina and Djato, 1994; Alderman, 1995). One of the important support services for increased production which is credit for equity capital, is usually inadequate in supply to meet the expenditure requirements for higher productivity and expanded production in agriculture (Al-Hassan, 1997).

3.4 Analysis of Food Security

Food security is only one element of livelihood security (Chambers,1988; and Maxwell and Smith,1992). These authors argue that indicators of food security should not be interpreted independently of a good understanding of livelihood security. The FAO defines food security to encompass "access to and availability of food, the distribution of resources to produce food, and the purchasing power to buy the food where it is not produced" (FAO 1996). The World Bank defines food security as 'enough food for an active, healthy life' (World Bank, 1986).

According to Sen (1982), food security is dependent on entitlement to food, through production, purchase, exchange or gift. Schuh (1997) added that food security is an income issue and is not, in general, a production issue. He said food security is primarily an issue of poverty. Because poverty is a central cause of hunger and malnutrition, Zyl and Kristen (1992) asserted the fact that special efforts are needed to help increase the access and entitlement to food. According to Maxwell (1996), a full definition of food security includes the related concepts of access, sufficiency, security or vulnerability, and sustainability. "Sustainability" is in terms of having sufficient food all year round for farmers on an identifiable basis. Many communities of industrialized countries are well planned

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because of the food security they enjoy (James, 1995).

Economic adjustment policies have been largely concerned with improving price incentives to export crop producers (Cleaver, 1985). It is important to take a close look at all of the problems that require the attention of policy makers (Tsakok, 1990). Smith (1997) showed that production shocks cannot be wished away because its effects have to be absorbed somewhere within the economic system. Smith said the effects of production instability result in instability elsewhere in the economic system. Many forms of government intervention in agriculture will distort market signals (Canning and Vroomen, 1996). However, appropriate government policies can provide the enabling environment for sustained production.

An important factor to consider in policy analysis and intervention is whether or not the country is a small or large country economically. Thus, do changes in their prices and production affect the rest of the world? In a small country, a production shock has little overall effect on the rest of the world, nonetheless, it has implications for farmer income and for balance of payments. Ghana can be considered as a small country in many respects because of the inability to affect world market prices in most of the commodities traded.

According to Zyl and Kristen (1992), increasing food production, storage and trade can improve food availability, but will not automatically ensure that all people have enough to eat and end hunger. In the same way, food self-sufficiency will not automatically ensure that people have enough to eat. The state of being food secure is not just a matter of sufficient supply, but ready access at all times; availability and accessibility of food must always go together.

Different methods have been used to measure food security. Economists use the disappearance method whereby they estimate gross household production and purchases over a period of time, estimate the growth or depletion of food stocks and presume that all

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the food that disappeared was consumed (Maxwell, 1996). In this study, food production levels are determined and the amount consumed and given away as gift are accounted for. The amount purchased to supplement production was also observed. Many of those who bought food did so just before the major season crop was harvested. Emphasis is laid on issues of production rather than intra-household relationships, which is not within the scope of this study. Intra-household relationships are important because it reflects how and what resources are shared. Food distribution can be poor even at the household level, thereby affecting household food security.

Solutions to food insecurity are multi-sectoral and require multi-disciplinary initiatives (Maxwell, 1997). Though agricultural production is a factor in determining hunger, it is not the only cause. Poverty or lack of resource entitlement, such as access to land, credit, income and support services, is an important cause of hunger and starvation (Sen, 1977). It is important to ensure that food production levels increase but it is more important to promote efficient distribution networks to avoid large inequalities. All sectors of the economy must therefore be equipped to address the problem of food insecurity in their activities. The findings of Arnade (1996) becomes applicable here, who carried out an inter-sectoral analysis of the US economy and found that the manufacturing and services sectors of the US economy had a significant influence on aggregate agricultural output. A good start in achieving this aim is to start with a thorough investigation of the farm sector at the micro level.

The debate on whether or not farmers use and will use their additional income to purchase food must be addressed. Education of children, medical expenses and clothing are the major areas in which farmers spend their income. In Ghana, many people (farmers and non-farm workers) prefer to produce the food they consume than purchase it. When people have access to land, they engage in minor farming activities to serve their food needs. For most farmers, purchasing food does not seem to be the answer to the problem.

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Though the production of cash and export crops must not be neglected due to their important contribution to national development, they need not be promoted in preference to food production. Producing food ensures that the farmer has economic access to food, either through direct subsistence or local exchange. A characteristic of peasant farmers is that, they do not often use their income to purchase food that they can produce.

3.4.1 Food Security and Poverty

According to Amoako (1998), integrated policy programmes that deal with the issues of agriculture, population and the environment are the basics to reducing poverty. Poverty refers to a state in which one is unable to obtain basic necessities required to sustain a minimally adequate standard of living. The annual income levels that determine whether or not one is living in poverty differ from country to country. As mentioned earlier, poverty in Ghana is predominantly a rural phenomenon. The World Bank observes that although urban poverty is growing rapidly, the poor in Africa are still overwhelmingly found in rural areas. The most crucial questions for developing any country's poverty alleviation policy are: who are the poor and where are they located (World Bank, 1997b)? In Ghana, about 65 percent of the population live in rural areas and 27 percent live in urban areas excluding Accra (Boateng, Ewusi, Kanbur, and Mckay, 1990). Fifty-nine percent of the labour force have their main occupation in agriculture (Asenso-Okyere, Asante and Gyekye, 1993), and agriculture contributes largely to the GDP of the nation (MoFA, 1997). Yet most of these rural farmers continue to be poor.

Haddad, Kennedy and Sullivan (1994) identified some indicators which can be used as predictors for food insecurity at the household level, including asset ownership, household size and dependency ratio. As mentioned in Chapter 1, the World Bank observed that average household size and dependency ratios are higher in rural than in urban areas (World Bank, 1997b). Food insecurity is therefore closely related to poverty.

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The Bank concluded that food insecurity among millions of poor people is caused by a lack of purchasing power and recommended measures for enhancing both chronic and transitory food security (World Bank, 1986).

It is worth mentioning that countries in the Third World were experiencing economic growth but realized that it was often not changing the state of the poor. Unemployment is increasing and rural-urban drift is on the rise. Using increases in GNP as the major objective of economic activity to achieve a rapid economic growth had failed to eliminate or even reduce absolute poverty. It was noted back in early 1970s that taking care of poverty first will take care of the growth in output (Mahbub ul Huq, 1971). When production levels increase, it does not tell us what type of goods are being produced in larger quantities nor information about the distribution of income among groups.

3.5 Empirical Analysis for Farmer Decision Making

Models for analysing farmers' income levels and productivity should of necessity be of practical workable nature. Tibaijuka (1994) noted that, if policy formulation in the 1990s and beyond in most of Sub-Saharan Africa is to aim at improving economic management, then attention must shift from descriptive to prescriptive analysis. Peasant farmers are rational decision makers and the issue ought no longer be to prove whether farmers respond to price incentives, but whether the incentives are high enough to warrant positive response, and whether there are other bottlenecks that limit the efficient allocation of resources and therefore the response to incentives (Cleaver, 1985).

While theoretical insights have been useful in providing a better understanding of the working of rural societies for policy makers, none has generated an operational framework that would guide both peasant farmers and policy makers as to how to optimize their objectives (Tibaijuka, 1994).

The model for analysis for this research needs to take the decision making

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approach, while at the same time have the capacity to determine the relative profitability of different crop enterprises. Econometric methods, policy analysis matrix, partial budgeting and gross margin analysis are possible methods of analysis for this research.

Econometric models have treated only single farm outputs on the production side, neglecting decisions concerning crop compositions (Singh, and Janakiram, 1986). Again, econometric techniques measure supply response and assess the impact of structural adjustment on agriculture and rural households but failed to capture the problems of imperfect knowledge and accountability mechanisms. The econometric techniques also result in estimated elasticities which are misleading for the design of alternative approaches to adjustment, especially in the fight against poverty (Tibaijuka, 1994, and De Janvry and Sadoulet, 1992).

Farmers have need of determining the optimal activities of the farm that would lead to the best possible farm income levels with the resources available to them. Dent, Harrison and Woodford (1986) noted that, for some planning problems, it is not feasible to determine the optimal activity levels by whole farm budgeting, partial budgeting or gross margin analysis. These methods do not permit a rigorous search for all combinations of activity levels nor a systematic approach towards determination of the optimal combination. The policy analysis matrix would not serve the purposes of this study as the scope does not include determining inter-regional relationships in production and movements of produce.

These limitations are overcome with the use of a linear programming method of analysis. Linear programming methods capture multicropping activities, which is the main system of farming in Ghana. Planting a variety of crops is a way in which farmers hedge against uncertainty. Thus, linear programming is suitable for analysing the farm situation typical of the Ghanaian farm setup.

Society evolves as a continual process of transformation in which people

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collectively enquire, evaluate and take action to change their life circumstances (Park, Brydon-Miller, Hall, and Jackson, 1989). Farmers need to be empowered with tools that will assist them in their decision making processes. Improving agricultural development assistance ought to take the decision making process of the farmer and the resources available to them into consideration.

Programming models encompass linear and non-linear programming. Vergani and Bogahawatte (1989) stated that mathematical programming models have proven particularly useful in the simulation of the impact of projects and the effect of new policies. Mathematical programming models are widely used for agricultural economic policy analysis (Howitt, 1995). He explained that mathematical programming models can be constructed from a minimal data set and the constraint structure is well suited to characterising resource, environmental or policy constraints.

Though some studies undertake a recursive programming to compare performance from one year to another, this approach requires data to be collected over a period of years because the majority of farmers in the study area do not keep records of their farm activities. To use this method, so many assumptions will have to be made, which reduces the validity of the results.

3.5.1 Relevance of Linear Programming Models

Hazell and Norton (1986) observed that many farm enterprises yield more than one product, and these joint relations can be modelled in linear programming (LP). This is particularly important in Ghanaian agriculture, which is typically multi-product rather than single enterprise. Dittoh and Ogunfowora (1987) recognised the need to analyse the profitability of crops in relation to other crops, though the farmer determines what crop combinations to cultivate. Others have argued that agricultural research should be refocused to center on improving the efficiency and output of mixed cropping practices,

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especially in developing countries where family farms seldom specialize in single-crop enterprises (Adesimi, 1991; Singh and Janakiram, 1986). Research findings such as that of Bulatovic (1997), who determined, by the use of an LP model, whether or not farmers should specialize in undertaking a particular farm activity, become very relevant.

A study by Adesimi (1991) in the Ogun State in Nigeria, revealed that intercropping of subsistence food crops is more profitable, efficient and practical than the cultivation of food crops in segregated stands. This finding is consistent with that of Dittoh and Ogunfowora (1987), who also found crop combinations to record high gross margins. In addressing wastewater treatment strategies, Carmichael (1998) found that existing models for policy analysis have considered only a single pollutant. These single issue models were limited in the analysis of multipollutant situations. The same applies to agriculture where there is the need to incorporate intercropping situations rather than focus on single crop farms in order to address the interaction among various crop enterprises and its policy implications.

Linear programming models applied to the farm situation can be summarized and the results communicated to the farmers to enable them understand the repercussions of their farm decisions. It can easily be explained to farmers in simple terms to serve as a practical guide in their decision making process. Though the implementation will require some farmer education to help them keep simple household records and perform basic mathematical calculations, it is not an unachievable goal. While some farmers have little education, others who have no education at all have someone in their household who can assist them in such an exercise.

Numerous researchers have used linear programming models to generate farm plans for farmers. LP is a practical tool to provide the farmer with a farm plan with which he can work and which will assist him in making decisions on what to produce and how much to produce. Elamin, Ibrahim, and Shomo (1997) determined an optimal farm plan

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for smallholder dryland farmers in North Kordofan State of Sudan with an LP analysis, and suggested that a farmer should plant more than half his total landholding with food crops, and then concentrate on the production of some specific cash crops. The purpose of their study was to find ways of resolving the food production situation in Sudan. The results of a linear programming model was used by Kabay and Zepeda (1991) to assess alternative production activities available to farmers in eastern Gambia. Nieuwoudt and Durham (1983) developed a linear programming model for dairy farms in Natal to provide planning guidelines for individual farmers.

LP models are therefore practical tools in farmer decision making. Findings from analyses using mathematical programming have resulted in policy recommendations on what farmers are able and likely to do under different conditions due to its ability to incorporate all possible enterprises (i.e. enterprises that farmers are likely to try integrating into their farming system). The results of the study by Kariuku (1990) in Swaziland clearly indicated that farm families were not likely to produce maize beyond subsistence requirements without a considerable increase in output prices. This information is vital to policy makers.

3.6 Empirical Analyses Using LP Models

Linear programming models can be used to analyse widely different agricultural and non-agricultural situations. Some of the applications of linear programming analysis are reviewed below and some of the findings are also presented.

Stonehouse, Weise, Sheardown, Gill, and Swanton(1996) used linear programming (LP) techniques to determine how net farm incomes compared across farming systems in Ontario, which is in Canada. They developed LP models for four farms using each farming system alternative. Foltz, Lee and Martin (1993) used a farm-level LP model to identify the optimal labour and machinery component, dividing the input use amounts into three

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categories: high input use, medium input use and low input use.

Other researchers have used size distinctions in LP analysis including Adesimi (1991), Kidane (1993), and Kabay and Zepeda (1991). Adesimi (1991) conducted a study in the Ogun State of Nigeria on smallholder farmers, Kidane examined resource allocation among competing enterprises in Kenya, and Kabay and Zepeda examined how farmers adjust production decisions given different resource endowments and under different rainfall conditions in Gambia. Tibaijuka had separate male and female labour rows in the base scenario, partially liberalised labour in the second scenario and fully liberalised male and female labour in the third scenario. Her results show that, in Tanzania, gender roles in sharing of farm work place a high premium on female labour and that if traditional division of labour is given up, average productivity of both labour and land would improve.

Dillon, Oriade and Parsch (1998) used a mathematical programming simulation to study potential and alternative production practices and rental arrangements for reducing production risk while improving both the tenant and landlord preferences. Carmichael (1998) used a simulation/optimization model to determine the optimal percentage of pollution abatement of multiple pollutants from industrial and municipal sources that meet downstream ambient quality constraints at the least cost.

In investigating a strategy of international shipments of maize from surplus to deficit areas, Nuppenau (1991) employed an LP model, also modelling the optimal intra-national transport schemes in Malawi, Zambia and Zimbabwe. He investigated trade patterns in the case of drought to demonstrate how regional trade contributes to national food security. He constructed a two-period model containing a normal year followed by a drought year. Benuneh, Deaton and Norton (1991) developed a two-year linear programming model for participant and non-participant households in the Food-for Work (FFW) project (a UN/FAO World Food Programme) in Kenya to compare the levels of their production activities, employment and income with and without the programme. They found out that the net

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income for the representative farm households in the programme was higher than those without it.

One major decision of the farmer is what to grow. To identify optimum and economically viable crop combinations for different types of farmers and on different soil types, linear programming technique can be employed in order to arrive at the maximization of the farmer's annual net profit from the use of available resources. Darasa, Odhiambo, and Mbatia (1992) used gross margin analysis and linear programming techniques to identify the main factors causing the declining output of cotton in the Funyula Division of Busia District in Western Kenya. Nyaro (1990) also used an LP model to establish the best combination of enterprises within the smallholder coffee areas of Kenya.

Investigating the net benefits obtained by adding and replacing farm machines is a common extension application of linear programming (McCarl, Kline and Bender, 1990). They did not directly apply shadow prices because shadow prices are indicators of the marginal effect of altering a single right-hand side, while machinery changes can alter multiple rows.

Linear programming techniques can be extended beyond the farm level to the regional and sectoral level, as in studies by Klein, Freeze, and Walburger (1996); Meyer and Zyl (1992); Zyl (1989) and others. To analyse the comparative advantage of different regions in South Africa with respect to the production of certain agricultural commodities, Meyer and Zyl (1992) employed a regional linear programming model. Sectoral models are also useful in assessing the interrelationships among different sectors of the economy. Zyl (1989) considered the interrelationships in agricultural markets in Southern Africa with a sectoral linear programming model. In the United States, factors outside of agriculture were found to have had a greater effect on aggregate agricultural output than factors within the agricultural sector, with both manufacturing and services having significant influence on aggregate agricultural output (Arnade, 1996).

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Mathematical programming models are effective in analysing technology adoption. Technology prescriptions were analysed using LP as well as socio-economic and technical data on specific farms in Cameroon (Nyambeki, Deuson, and Lowenberg-Deboer, 1990). The analysis revealed the changes in farm returns as a result of partial or complete adoption of the technology. Kiriuku (1990) undertook a study of the impact of adoption of hybrid maize and compared the incomes, resource availabilities and use, farm household expenditures, enterprise combinations, food consumption, maize production and other characteristics of smallholder farms growing hybrid maize with those growing local maize varieties in three agroecological regions.

Linear programming models make the inclusion of constraints that help to bring out the issues close to the real life situation, thereby making the results more realistic. According to Ray and Bhadra (1993), one has to question the validity of the assumption that farmers are price-takers in all input markets and can buy any input bundle at the given price. Upon conducting a non-parametric cost minimization behaviour of Indian farmers, they found it difficult to explain why a farmer would be generally technically efficient but fail to select the cost-minimizing input bundle. Neglecting to incorporate real life issues into the agricultural model leads to incorrect conclusions. Thus many studies have found farmers to be making inefficient use of their resources, due to their farming decisions in the face of economic unprofitability. This realization led Seini (1985) to look beyond the results of his study to explain the finding within the socio-cultural environment in his study on poverty in Ghana using the Dagbong district as a case study.

3.6.1 Linear Programming and Resource Allocation

Farmers are faced with the challenge of allocating their limited resources among competing activities. Every farmer has a certain amount of resources available to him to engage in production activities in the farm. The farmer then needs to decide how much

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of each of the available resources to devote to the enterprises they wish to undertake. Kidane (1993) employed a linear programming model to investigate how resources can be allocated among competing enterprises in order to maximize farm income in Kenya. He developed models for small, medium and large farms to identify the economic constraint related to each farm size. Mathematical programming is one technique that can be used for resource policy appraisal (McCarl, 1992). Woubshet and Anderson (1990) for example used an LP model to address the resource allocation problem of the smallholder.

Linear programming models can constitute the basis for comparing alternative fertilizer allocation strategies as demonstrated in the analysis of El-Hajj and Saade (1992), who used estimated production functions to calculate the optimum fertilizer rates for different crops in Syria. The production functions were then incorporated in a separable linear programming model which allowed the calculation of optimum fertilizer rates under varying levels of the constraints on fertilizer availability.

When a region in South Africa faced the challenge of finding the optimal production system given resource constraints, Minaar and Groenewald (1990) used an LP model to determine the optimal livestock and cropping systems. The main problem in this region was the selection of optimal farming systems. In improving farmers' income and resource use, Debede (1997) employed a linear programming technique to investigate the economies of integrating a particular crop into the traditional farming system. Kabay and Zepeda (1991) modelled farmer response to different production and rainfall conditions in order to assess the effect of agricultural policies on food production and farmer income in Gambia. Thus, linear programming assists in determining the optimal crop combinations under different scenarios, given resource constraints, in order to maximize net farm returns.

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3.7 Summary of Literature Review

The use of linear programming technique is most appropriate for analysis when there are several crops competing for the same land and when interrelationships between several activities need to be considered (Zyl, 1989). The linear programming approach is effective in both micro and macro analysis. It is a cost-effective tool as it allows interaction between the production parameters, quantifies the impact of limiting factors by shadow prices and can also be used in simulation (Knipscheer, Menz, and Verinumbe, 1983). It is a practical, flexible and workable analytical tool.

In analysing whether or not it is advisable for the farmers to devote more resources to the production of maize in Ghana, LP models are the most effective. This procedure weighs the alternative enterprises and determines the change in net farm returns for forcing a production choice on farmers. There is the need to reconcile the desire for the production of more maize with the resulting changes in the income level of the farmers. A study by Okuneye (1985) using a programming model showed the amount by which net farm returns could be increased if resources were diverted towards the production of particular crop enterprises in Ogun State of Nigeria.

Similar to the work done by Dittoh and Ogunfowora (1987), this research analyses the relative profitability of various crops. The farmer can then make decisions knowing the opportunity cost of producing the crops he chooses to produce. Besides, since there is the need to move from theoretical insights and seek an operational framework, this research develops a linear programming model for analysing the relative profitability of food crop enterprises in the study area. The results will serve as a guide for both farmers and policy makers in their decision making and policy formulation. Together with the use of gross margin analysis, these tools will achieve the objectives of this research most effectively.

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Chapter Four

The Survey and Survey Results

4.1 Introduction

This chapter describes the case study area, survey and methods of data collection and reports the results of the survey. The chapter is divided into two main parts namely: the survey and survey results. Under the sections on the survey, the sampling procedure is presented and the survey exercise is described. The survey results presented in this chapter consists of descriptive statistics, farming systems and farmer characteristics in the Central Region of Ghana. Issues on gender, demography and selection of farmer groups for the analysis are presented. The survey results that relate to the model are discussed in Chapter Five.

A. The Survey

The survey was conducted to collect farmer-specific data to determine the socio-economic characteristics of farmers in the region, to analyse the relative profitability of the different enterprises and to provide information for constructing a linear programming matrix.

4.2 The Case Study Area

Maize is produced in every region in Ghana. Most regions in Ghana produce and consume maize as a major staple food crop. A study that analyses and demonstrates the importance of ensuring a maximum, continuous and sustained income level for maize farmers and the role of maize in food security in Ghana is therefore necessary for many parts of the country.

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This study is conducted in the high maize producing districts in the Central Region of Ghana. The reasons for choosing the study site are as follows. The Central Region is a large maize producing region in the country. It was the fifth largest maize producing region in the 1990s and the forth in the year 2000. The main maize producing districts in Ghana produce an average of about 10,000 metric tonnes per annum (MOFA, 2000). Five districts in the Central Region fall within this category. It therefore has the potential of increasing maize production.

Increasing maize production is critical for the Central Region because they consume a lot of maize in different forms such as *'kenkey'*, porridge and *'banku'*. As such, increased maize production can improve the food security situation in the region. It can also help to further reduce the poverty level, which had experienced large falls from 1987/88 to 1991/92 (Ghana Statistical Service, 1995a). The Central Region was also chosen based on the fact that the researcher is familiar with the region, having done earlier research there, and it was accessible considering time and resource availability.

The Central Region has a population of about 1.2 million people in 1998 with 3,144 square kilometers of land under cultivation, and has Cape Coast as its capital (see Ghana map on next page in Figure 4.1). Temperatures range between 24°C and 32 °C, humidity is 60% and rainfall is bimodal, which supports production in two seasons for most parts of the region.

The Central Region has three main agro-ecological zones: Coastal, Forest and Transition zones. It has 12 administrative districts (following the political districts) and maize is produced in all the districts, though the volume of production varies considerably. Maize is termed the 'main crop' and is a major staple food in most parts of the Region. Some districts such as Mfantsiman and Agona produce as well as consume a lot of maize, while a few districts such as Assin, Upper and Lower Denkyira produce a lot of maize for sale, consuming only a little with the rest being marketed. The people of the latter districts

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Figure 4.1 The Map of Ghana Showing the Central Region

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consume mostly fufu which is made from cassava, cocoyam and plantain. From among the high maize producing districts, three districts were randomly selected for the analysis namely: Agona, Assin and Mfantsiman districts.

4.3 Methods of Data Collection

4.3.1 Sampling Procedure

A multistage sampling method was used to select the farmers for the study. Data from the Policy Planning, Monitoring, and Evaluation Department (PPMED) of the Ministry of Food and Agriculture (MOFA) showed the low and high maize production districts in the country. Since this study focuses attention on the potential of the maize enterprise in relation to other enterprises, the high maize production districts were considered. Out of the high maize production districts, three districts were randomly selected: Agona, Assin, and Mfantsiman districts. The Agona and Assin districts fall under the forest zone while the Mfantsiman district falls within both Coastal and Transition zones.

Five villages/towns were randomly selected from each district. From each of the five villages, 7 farmers were interviewed with the exception of one village in the Assin District where 6 farmers were interviewed and another village in the Agona district where 8 farmers were interviewed. In all, a total of 105 farmers were interviewed. The selection of the farmers at the village/town level was on the basis that the farmer produced some maize. There was stratification in the farmers selected using farm size and gender as controls. At least 3 of the farmers interviewed in a village/town were women, resulting in at least 43% of the farmers interviewed in each village being made up of women. The farmers fall within three categories namely: large, medium and small scale, and farmers were randomly selected from all categories.

Figure 4.2 presents the sample distribution by gender. From the figure, about 45

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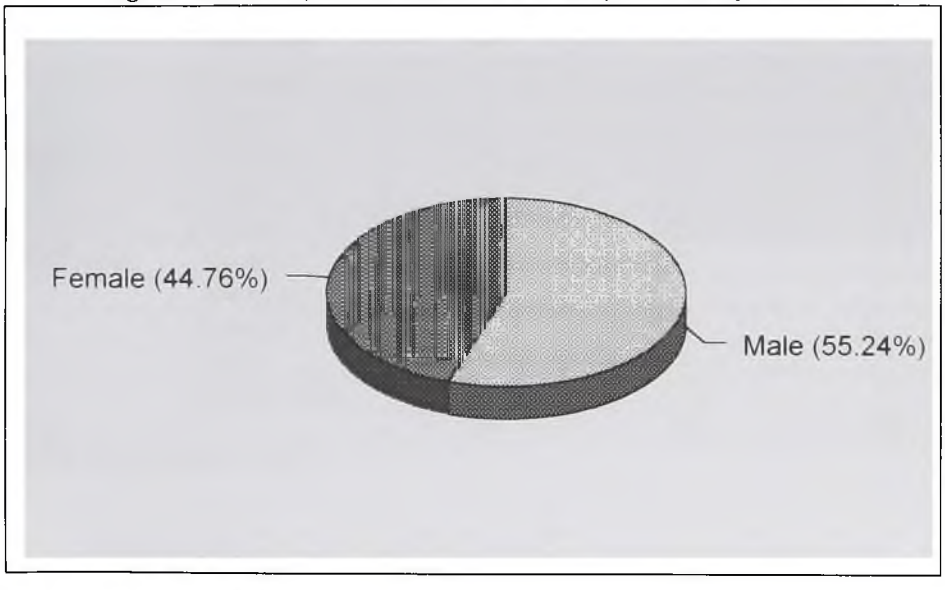
percent of the farmers are female and 55 percent are men. Farms that fall within the large scale category had food crop farms of more than 5 acres (ranging up to 14 acres), medium scale is between 2.5 to 5 acres, and small scale is between 1 to 2.5 acres. The average farm sizes for the Mfantsiman district are somewhat smaller than those in Assin and Agona districts because Mfantsiman is a relatively poor district. Field sizes were obtained but the fields were not measured nor the density of each crop planted estimated. Table 4.1 shows the villages that were selected for the interviews in the various districts and the number of male and female farmers selected in each village. Farmers are more concentrated in smaller towns than the larger ones as trading and other commercial activities are prevalent in the larger towns such as Agona Swedru. Equal allocations of farmers in each village was used because information on farmer population in each village/town was also not available to allow for proportional sampling, which requires that the population of farmers are known.

Figure 4.2. Sample Distribution of the Respondents by Gender



Source: Field Survey, 1998

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Farmers who have farms less than 1 pole (a system of measure used in a number of villages which is equivalent to about three quarters of an acre) were not considered and were classified as hobby farmers even though the farmers do not regard their farms it as such. "Micro" farms would be an appropriate way of referring to these category of farms. These farms are purely subsistence and hardly have any surplus produce for sale. They do not expand their farm enterprises and remain the same from year to year, with very little resources to work with. Enterprises of these farms cannot effectively be included in this study as determining the relative profitability of different enterprises is one of the objectives of the study.

Table 4.1 Sample Distribution of Respondents by District and by Gender

District	Village	Sample		
		Male	Female	Total
Assin	Akonfudi	4	3	7
	Breku	4	3	7
	Manso	4	3	7
	Damang	4	3	7
	Akropong	4	3	7
Agona	Kwesikum	4	3	7
	Swedru	4	2	6
	Nyarkrom	4	3	7
	Nsaba	3	4	7
	Nkum	4	4	8
Mfantsiman	Nsuetyir	4	3	7
	Mankesim	4	3	7
	Duadze	4	3	7
	Krofu	4	3	7
	Ekumfi-Abor	4	3	7
Total		59	46	105

Source: Field Survey, 1998

4.3.2 The Survey Exercise

The survey was conducted including farmers who grow maize as an individual crop or as an intercrop in the study area. An interview schedule was designed for data

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collection to capture the main variables in the model to ensure the achievement of the set objectives of the study. The interview schedule is reproduced in Appendix I. The use of interviews made it possible to make observations and clarify issues emerging with respondents. The interview schedule was pre-tested on 15 farmers (both men and women) in the study area and refined before the actual data collection exercise.

The method of data collection was rather expensive and time consuming. However, it ensured that quality data was obtained first-hand for the analysis. The exercise was somewhat participatory in approach because the researcher has a farming background and could identify with the farmers in a particular way. Most of the farmers were very desirous to discuss their farm work with a female researcher and the women farmers were especially delighted to discuss their concerns and problems with a woman who they perceived to understand the importance of household food security and who had once been a farmer. They were even more pleased to realise that the researcher pursues issues that pertain to promoting agricultural productivity among women. The choice of the survey method allowed selected staff of the Ministry of Food and Agriculture, who were trained by the researcher, to participate in the data collection activity. An undergraduate research assistant was also employed for the purposes of data collection. The field assistants were closely supervised and the schedules they administered were examined for clarity, consistency, accuracy and completeness of their entries.

The data collection was a challenging exercise. Several visits had to be made to some villages in order to get in touch with the farmers and to obtain complete information where there has been omissions or unclear information. Most of the farmers were followed to their farms in order to carry out the interview with them. Each interview lasted between 45 minutes and 2.5 hours and we left some villages very late in the night. Each completed schedule was cross-checked, and reviewed several times to ensure data precision and accuracy in data entry and analysis.

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4.3.3 Description of Survey Data

There were structured, semi-structured and open ended questions used for the data collection, making it possible to collect both qualitative and quantitative data. The respondents were allowed to describe, where desirable, some of the realities on the farm. They gave detailed description of their processes and problems in different areas of their farming activities without restriction and expressed their major concerns not only on situations they were asked about but also on issues of general interest to the farmers.

The data is mostly primary and collected from a survey but secondary data were also collected. Data were collected and organized on prices, crop yields, cash investments in the farm enterprise, fertilizer use, level and use of other resources, and farm size, among others. Data was also collected on the demography of the farmers and their household characteristics.

Hanf (1989) stressed that the best real data sources can provide only a small fraction of the data which is needed to formulate a linear programming model. There are only very few data, he said, which may be directly derived from farm reports, which are labour, land and aggregate capital, and in some cases the yield of some crops, which sometimes need to be modified in modelling. As such, a lot of the information used in the LP model building in this research are from the survey results, but some are arrived at after making some calculations and other considerations.

The data is micro-level data. If research intends to make inferences from a model regarding individual behaviour, then a micro-level specification is generally preferred because aggregation can introduce bias in coefficient estimates and could also result in unrepresentative parameter estimates and poor forecasting ability. (Park and Garcia, 1994). Aggregation has received considerable attention particularly in the demand literature, focussing on the conditions under which it is possible to treat aggregate consumer behaviour as if it were the outcome of decisions of a single maximizing

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consumer. These conditions are derived because information does not exist on individual consumer expenditures (Deaton and Muellbauer, 1980).

Secondary data for the linear programming model were also collected from Extension and PPMED Departments of the MOFA in Cape Coast and Accra, including area cultivated, yield, production, wholesale and farm-gate prices (regional averages) of some major crops for the Central Region and at the national level. The secondary data validates as well as complements the primary data. SPSS statistical and Microsoft Excel softwares were used for data entry, descriptive analysis and calculations to obtain per acre values for building the linear programming matrices. The linear programming matrices were solved using Quattro Pro spreadsheet software.

Maize farmers' net income is affected by the price they obtain for the produce, the level of output, the prices of substitutes, price of inputs and other costs of production. The amount of capital available to the farmer, level of investment in the farm, size of farm, and level of input use provide insights into farmer decision making process. Collecting data on the level of input use is to show whether or not recommended quantities of inputs such as fertilizer and herbicides are applied by farmers. The availability of storage facilities and other infrastructure affect the price the farmer obtains for maize because it determines the time of sale. The price of maize and ease of producing other farm products determines the ability to switch resources from maize production to the production of other crops.

B. Survey Results

An important part of the analysis in this research is a detailed qualitative, descriptive analysis of the socio-economic characteristics of the farmers. The second part is the empirical analysis. It is difficult to assess the views of farmers without a thorough qualitative analysis and a study of their socio-economic circumstances. The qualitative analysis helps explain the quantitative results and categorize farmers for the linear

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programming analysis and simulation.

The demographic characteristics of the farmers are presented by gender. The differences and similarities between male and female farmers are discussed in terms of their farm sizes, types of crops grown, input use levels, yield and output levels. The responses of male and female farmers to agricultural policies are studied, making inferences from the choices these farmers make in response to policy shocks such as changes in prices of inputs (eg. fertilizer). The performance of male and female farmers who received agricultural assistance are analysed.

Agricultural assistance were provided by the Ministry of Food and Agriculture, Adventist Development and Relief Agency (ADRA), Sasakawa Global 2000 (SG2000), and the Central Development Commission (CEDECOM) whereby inputs such as seed, fertilizer, herbicides, cashew seedlings and in some cases, technical assistance are provided to the farmers. The term "agricultural assistance" will be used interchangeably with participation in agricultural programmes/projects. The farmer characteristics and differences in resource endowment and use by gender and participation in agricultural programmes were utilised as the basis for identifying the groups of farmers to be used for the linear programming analysis. The selection of the groups of farmers is discussed in further detail in section 4.9.

4.4 Farming Systems in the Central Region

The farmers in the study area engage in both on-farm and off-farm activities, but mostly in farming activities. Off-farm work is done to provide additional income for children education, clothing and to serve as financial security in the cases of funerals and unforseen expenditures. Some of their off-farm activities are trading, teaching, carpentry and palm oil production.

The farming system that characterizes the Central Region can be termed as maize-based, with cassava, plantain and cocoyam being important crops. In two villages in the

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Mfantsiman district, garden-eggs (or egg plant) is the most important crop, with maize, cassava, and other vegetables being in the cropping system. Other food crops in the region include yam, pepper and tomatoes.

Maize is either grown as an individual crop or in combination with other crops; in almost any combination. When maize is grown with vegetables, the maize is usually planted early, harvested and then the vegetable is planted on the field. This is known as relay cropping. A few of the farmers planted tomatoes under the maize (known as inter-cropping) in which case the farm is thoroughly weeded during the harvesting of the maize. The farmers also engage in the production of tree crops and other perennial crops such as pineapples. The tree crops grown in the area include cocoa, coffee, citrus, and oil palm.

As mentioned earlier, all the farmers surveyed planted maize, and though the size of farms differed from farmer to farmer and between male and female farmers, farmers of both genders grew similar crops. The crop combinations selected for analysis are shown in the Chapter Five.

Due to shifting cultivation and mixed cropping, most farmers only plant maize on the same plot once or twice and then move to another location. Cassava, plantain and other crops which were planted with maize occupy the land after the maize is harvested. The farmer moves back to the land to plant maize after harvesting the cassava in the following year. For the farmers planting tree crops and other perennial crops, the land is gradually held permanently after a few cropping seasons. Farmers generally refer to tree crops and perennial crops as 'projects', and these projects constitute their assets and security for the future.

A number of export crops are being introduced to the farmers such as black pepper, cashew and acacia. The farmers have little information about marketing of these produce. They also have to wait for about three years before these crops are harvested. The income from maize, most farmers have confirmed, is quick and regular. Considering the

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small land holdings of a majority of the farmers, programmes that promote the cultivation of cashew and acacia may not benefit small scale farmers who have limited access to land. Holding the land with perennial crops leaves some of the farmers landless and may have implications for food security.

Irrigation is not practiced in the area, except that some vegetable farmers do manual watering with buckets at the early stages of the crops. Neither do the farmers have drainage systems in place to guard against floods. This lack of irrigation and drainage systems has resulted in complete crop failures in some seasons when there was not enough rain or when there has been too much rain.

4.4.1 Seasonality

Maize is produced twice a year (i.e. in both major and minor seasons) in most parts of the Central Region. However, only one season is possible in certain areas where rainfall is unimodal in its distribution. The major season is the main season for planting most crops because it is usually characterized by sufficient rainfall. This season begins as early as January and ends in August. The first maize (or early maize)[1] is planted at the beginning of March and planting may continue till May (i.e. late crop). Staggered planting is practiced whereby a farmer plants some maize in March, some in April and some in May, depending on how much land preparation was done before the season began and prevailing rainfall patterns. Another reason for planting maize at different times is to insure against crop failure. There are times when the rains fail for the early maize and all the crop is lost. Sometimes, people have to replant the whole farm if they are to obtain any harvest. There is a high element of risk in farming and farmers are known to be risk averse.

The latest maize for the major season is harvested in August and the minor season

[1]There are swampy areas where maize can be planted as early as December but this is not the usual pattern.

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planting starts in September. The minor season is rather short, has a short period for planning and tight working schedules are needed. Farm sizes are smaller for the minor season because farmers do not have as much time for land preparation as the time available for the major cropping season. Rainfall in the minor season is light and a number of farmers do not undertake new farm projects, devoting most of their time and other resources to maintaining the cassava, plantain and cocoyam that were cropped together with the maize during the major cropping season. Yields are generally lower and smaller technical coefficients are appropriate for the minor season. The minor season ends in December. Due to the differences in the cropping patterns in the major and minor seasons, the question of seasonal resource availability becomes important.

4.4.2 The Importance of Maize to Farmers

Every year, almost all farmers interviewed grow some maize in the two cropping seasons. Visits to the farmers and dialogues with them revealed the reasons why they always grow some maize in every cropping season. Maize is their main or traditional crop and they grow some amount of it no matter what crops they want to focus on. To a few women farmers, maize is described as a 'good mother' They wondered how they can take care of the food needs of the home without maize from their farms. Buying maize, some farmers said, is a very undesirable situation for them and they produce their own even if the yield is low. Maize availability to these farmers give them assurance of food security. It is the most important cereal crop and the major staple food, not only in the Central Region, but in most parts of the country.

Traditional and cultural beliefs of the people cannot be ignored in assessing why they farm the way they do. There also exists emotional attachment to certain crops which are grown without any economic consideration. Among most farming families in Ghana, maize is always produced every year with the main reason for its production being for food

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security. They cannot bear purchasing maize as farmers. They are therefore disappointed when some of them have to buy maize for consumption when their stock is finished. Some farmers said they reduce consumption levels and switch to the consumption of other farm produce because it is very undesirable for them to buy maize.

For financial security, maize is grown because it is quick maturing, brings quick and regular income, and can also be stored and sold whenever financial needs arise. Export crops serve a different purpose, in that they bring in a bulk of money only once in a while. Farmers would rather have money coming in regularly and uniformly.

There were a few large scale poultry farmers in the sample. These farmers grow maize to use as feed for the chicken and the rest for home consumption. They do not sell the maize. Their income is from the proceeds of the sale of the birds.

4.4.3 Land and Land Tenure Systems

The following types of land ownership were found in the study area:

i. Family land ownership: the farmer pays no rent on the land (see Table 4.8) They are referred to as 'not applicable' in the table as they do not pay anything.

ii. Purchased land: the farmer had bought the land and therefore pays no rent on the land.

iii. Rented land: here the farmer pays a fixed amount for using the land in the form of rent.

iv. Shared Cropping: this is prevalent among farmers in the sample. It is the system whereby output is shared between the farmer and the land owner. There are two types of share cropping practiced in the area known as *abusa* and *abunu*. In the *abusa* system, the output is divided into three parts and the farmer keeps two-thirds, giving one-third to the landowner. In the *abunu* system, the output is divided into two equal parts between the farmer and the landowner. In the abunu and

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abusa system, the land does not belong to the farmer (refer to Table 4.3 for distribution). He only farms on it and the produce is shared with the landlord.

Family land forms the main type of land ownership. About 46 percent of the farmers use only family land. Another 19 percent have a greater proportion of land holding as family land but have other types of land ownership system (rented, purchased and sharecropping) (see Table 4.2). About 31 percent of the farmers have at least part of their land being under the share cropping system. Purchased land is the most uncommon type of farmland ownership. Those who use rented land pay a fixed mount of money for a cropping season, a year, or as agreed upon between the farmer and the land owner.

Table 4.2 Types of Land Ownership in the Study Area

Ownership Type	Frequency	Percent
Family land	48	45.7
Share cropping	16	15.2
Rent	13	12.4
Family/ Share crop	8	7.6
Rent/ Family	7	6.7
Rent, Share cropping	5	4.8
Family, Share cropping	3	2.9
Purchased land	3	2.9
Rent, Family, Purchase	1	1
Not Filled	1	1
Total	105	100

Source: Calculated from Field Survey, 1998

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Table 4.3 Terms of Payment for Land Use in the Central Region of Ghana

Terms		Frequency	Percent
Not Applicable		50	47.6
Pay fixed amount/ leasehold		23	21.9
Share cropping:	Abunu	13	12.4
	Abusa	10	9.5
	Abusa. abunu	6	5.7
Rent/ Share Crop:	Abunu, fixed amount	3	2.9
Total		105	100

Source: Calculated from Field Survey, 1998

4.4.4 Fertilizer Usage

Of the total respondents, 54 percent reported to have used fertilizer in 1998. The remaining farmers either never used fertilizer, or have once used it but stopped for different reasons. Some reasons given for not using fertilizer include:

a. 'I cannot afford it';

b. "I am not interested", They are simply "not interested", some due to ignorance and others due to conservative beliefs.

c. "The price is too high"

d. "Fertilizer spoils my crops"; These farmers claim that the food does not taste well when they apply fertilizer to the crops. Further, cassava is reported to get rotten when fertilizer is applied to it.

e. "My land is fertile and does not need fertilizer"; and

f. "I have no knowledge about it"

The farmers were also asked what they would do if the price of fertilizer increases. Twenty-six percent of those who were currently using fertilizer said they will stop using it, 28 percent said they will reduce the amount used, while 39 percent said they will still buy it. Sixty-five percent of those who were not using fertilizer reported that they were not interested. When asked what they would do if the price decreases, 68 percent of users

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said they will increase the amount used and if possible, use recommended quantities. Among those who were non-users, 35 percent reported that they will try using it though they have never used fertilizer. These responses were not based on economic calculations. However, the implications of price being the main reason for lack of interest in the use of fertilizers is that a decrease in the price of fertilizer will undoubtedly result in increased use.

The male fertilizer users reported higher yields for maize and vegetables than those who do not use it. However, the women farmers output levels did not follow this pattern. Those who did not use fertilizer had higher yields for maize than those who used it. This may be explained by the fact that most of the women who farm on a large scale, farm on more fertile lands, leading to higher yields without the use of fertilizer. The output of cassava, cocoyam and plantain do not depend much on fertilizer application. Fertilizer is applied to these crops only when they are inter-cropped with maize or vegetables.

The yield of the various crops are presented in Table 4.4. Weight conversions of the Standard Board are as follows: 1 minibag of maize is 50kg, 1 minibag of cowpea is 54.5kg, and 1 minibag of cassava is 45.5 kg. (MOFA/GTZ, 1997). The output from plantain that is mixed with maize is almost equivalent to that of individually-cultivated plantain because the plantain quickly becomes an individual crop once the maize is harvested.

It must be noted that the behaviour of the farmers is very diverse, and the central tendencies are being used for the purposes of discussion. It was observed that those who used fertilizer also spent more money on farm tools than non-users. Fertilizer users received very little loan for their farming activities in the farming season of 1998, yet they obtained more income out of farming activities than the non-fertilizer users. This implies that the use of fertilizer results in higher incomes for farmers.

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Table 4.4 Crop Yields in the Study Area for Major Season of 1998*

Crop	Male		Female		With Assistance		Without Assistance	
	Individual	Mixed	Individual	Mixed	Individual	Mixed	Individual	Mixed
Maize (Mini-bags)	15	12.5	13	11.5	13.5	12	11.5	10
Minor Season Maize	11.5	11	10.5	10	10	9	8.5	8
Cassava (Mini-bags)	20	17	23	18	23	18	24	17
Plantain (bundles)	240	150	230	160	150	112	225	154
Cocoyam (bags)	12	12	18	18	22	12.5	22	12.5
Tomatoes (crates)	45	40	56	52	42	34	53	29
Pepper (Mini-bags)	24	18	34	25	40	32	45	24
Garden eggs (Mini-bags)	160	115	60	52	145	85	120	95
Cowpea (Mini-bags)	5	4	6	4.5	6	2.5	4	3

Source: Field Survey, 1998
*These are the total weighted averages

4.5 Major Problems Identified by Farmers

Lack of sufficient funds for farming activities was the major problem identified by farmers in the Central Region. Eighty percent of the total respondents said they have a problem with capital. Problems related with input acquisition were expressed by 34 percent of the farmers. Input related problems are directly linked with the problem of insufficient funds as it determines the purchasing power for acquiring inputs. Finances are also needed for hiring labour (for clearing, weeding and harvesting of crops), renting land and construction of storage facilities.

Marketing problems come in the form of non-availability of transport to convey produce to the marketing locations, poor roads leading to and from the farming villages, and money to pay for transport charges. Some of the farmers sell the produce on credit and payment becomes a problem. Other farmers complained of lack of available and ready market. Almost all the farmers expressed marketing difficulty in one way or the other. Seven farmers mentioned the problem of transportation.

Labour related problems form another principal problem area (see Table 4.5). Again, the money for hiring labour and the problem of high cost of labour was expressed

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by 41 percent of the respondents. Fifteen percent said that labour is not always available, while 30 percent said that the labourers are not reliable. Many of the labourers could promise coming to weed and not show up at all, and yet others will take advance payment and refuse to do the work.

Table 4.5 Problems of Mobilizing Labour

Problem	Frequency	Percent
None	12	11.4
Financial (to hire and feed)	29	27.6
Labourers are not reliable	25	23.8
Labourers are not always available	16	15.2
Expensive / Scarce	11	10.5
Labour very expensive	3	2.9
Scarce and not reliable	7	6.7
Other	1	1
Total	105	100

4.6 Demography and Social Status of Respondents

The respondents mainly fall within the ages of 41 to 55 years of age, with this range accounting for 43 percent of all respondents. Eleven percent are under 30 years of age, 28 percent are between 30 and 40 years, and the oldest farmer was a man who was 80 years old. It is encouraging to find that a few are young industrious farmers who have the ability to improve upon their farming activities if measures are put in place to improve their performance, such as appropriate policy, development of rural infrastructure, and other incentives for farming.

The average size of a household is 8 persons, while household economic farm labour force (people who are available to work on the farm as family labour) is 3 persons. Eighty seven percent of the respondents said they were married. Only one man said he was divorced, while 8 females reported to be divorced and 5 women were widowed (Table

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4.6).

Significant differences were found in the access to education among the farmers by gender. About 46% of the women never had any formal education (i.e. never went to school), compared to only 3 male farmers (i.e. 0.05%). Among the women, 11 had just a primary school education, and 2 had a college education (Table 4.6). One male farmer had a university degree, 6 attended College, and another 6 had other forms of higher education, whereas only 2 women went to college.

Adesina and Djato (1994) concluded from a study in Cote d'Ivoire that the issue of whether farmer education significantly enhances efficiency in production is debatable. However, education enhances farmer's abilities to manage the farm more efficiently as they are able to keep simple and good records if they are encouraged to do so. Again, women are the most affected in this area. The respondents were mostly christians (87 percent). Ten farmers were moslems and 3 were of other religious backgrounds (see Table 4.7).

Table 4.6 Level of Education of Respondents

Level of education	MALE		FEMALE	
	Frequency	Percent	Frequency	Percent
Never had formal education	3	5	21	46
Primary school level	10	17	11	24
Middle school level	28	48	8	17
Secondary (O & A) levels	5	9	3	7
College (Teacher, Technical, Vocational)	6	10	2	4
University degree	1	2	0	0
Other	6	10	1	2
Total	59	100	46	100

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Table 4.7 Marital Status and Religion of Farmers in the Central Region of Ghana

		Male		Female		Total
		Freq.	Percent	Freq.	Percent	Freq.
Marital Status	Married	57	97	30	65	87
	Single	1	2	3	7	4
	Divorced	1	2	8	17	9
	Widowed	0	0	5	11	5
Religion	Christian	51	86	41	89	91
	Moslem	5	9	5	11	10
	Other	3	5	0	0	3

4.7 Gender Issues Among Respondents

Three categories of women were identified: i) women who are co-working with their husbands but have their own farms as well; ii) women for whom the husbands clear the land and they take over the farms for themselves; and iii) women who are purely independent as is the case of widows, polygamous marriages, the divorced or when the husband has travelled for an extended period of time (such as when he is a migrant). Women in Ghana bear the primary responsibility of food production and devote a greater proportion of their farm produce for home consumption. It was therefore critical to ensure that women are well represented in the sample for a thorough gender differential analysis to be undertaken.

The distribution of farm sizes according to ranges are shown in Figure 4.3. Majority of women farmer fall within farm sizes up to 2.5 acres while majority of male farmers fall within the category of 2.5 to 5 acres.

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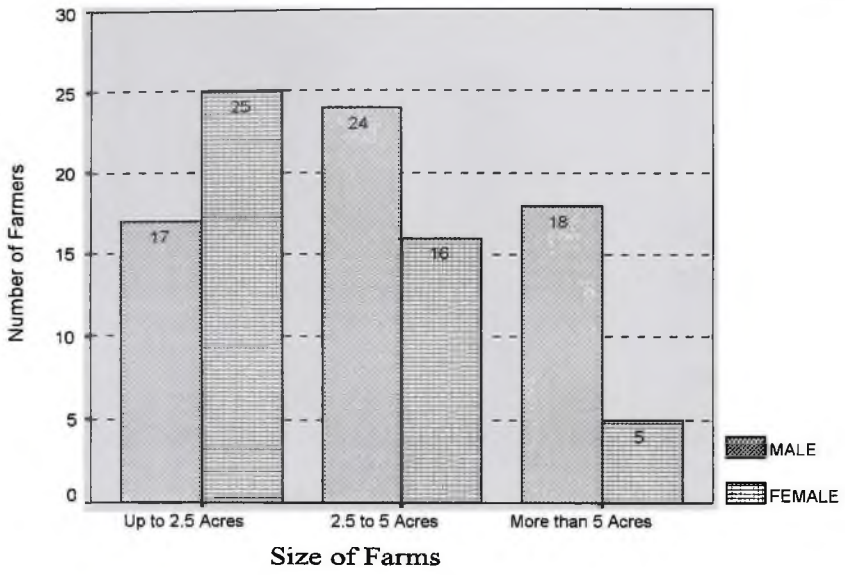
Figure 4.3 Food Crop Farm Sizes of Respondents by Gender (1998)



The amount of maize harvested differs significantly by gender (see Figure 4.4). No female farmer had total maize harvest of over 50 minibags. The distribution for the male farmers looks normal while that of females is skewed to the right, showing that as the size of harvest increases, the number of women in the category is reduced. Promoting female farm enterprises may improve rural household food security situation in Ghana. There is evidence that the amount of maize harvested depended strongly on the size of the food crop farm, the amount of money the farmer said he/she set aside for farming purposes at the beginning of the year, and gender.

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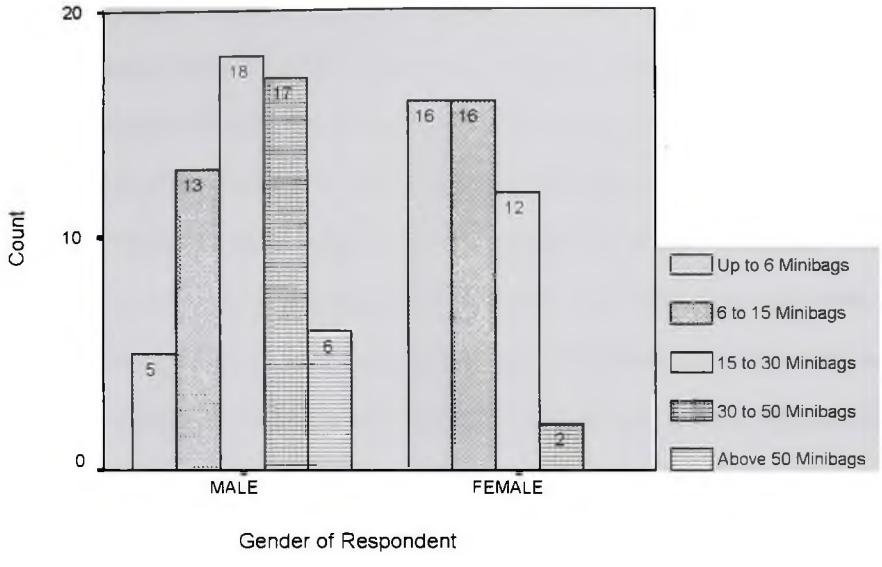
Figure 4.4 Maize Harvest by Gender



Some intra-household issues were addressed in the survey. It was found that some families make decisions together as a unit while others did not. The relationship among the family members and the nature of the farm ownership arrangements determine the amount of food contributed by each member towards household consumption. As mentioned earlier, some of the women are single mothers, widows or with absentee husbands. These women do everything on their own with no assistance from a husband. A man in the Agona district referred most of the questions addressed to him to his wife to answer. The woman was well informed about all the farm activities: resource use, harvest information, income, time of planting and others. She also had a farm which belonged to her and the husband helps her on it. There was a farmer whose wife does not go to the farm at all because she had a different profession. Though some of the wives of male farmers may be traders, they do help on the farm once in a while.

Seven women (15% of the women respondents) said their husbands help them in clearing the land and in planting the crops, and 12 women said their husbands help in all

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aspects of the farming. When the husband clears the land for the wife to the planting stage, the woman takes over from there and has autonomy over the farm. The output and proceeds from these farms belong to the woman and she decides what to do with it. However, the women use a greater proportion of their output as food for the household than men do. In the male enterprises, the women usually undertake the marketing of farm produce. The situation varies depending on whether the man is monogamous or polygamous; a few of the men interviewed said they had more than one wife. In polygamous situations, the woman uses even more of her farm produce as food because she has to provide almost all the food for her own children with the husband probably helping only once in a while.

Over 50 percent of the farmers had never applied for a loan. Only 6 women in the sample used herbicides. One lady quite honestly said she did not weed one of her farms in the major season of 1998 because there was no family labour nor money available for hired labour. She did not access her resources at the beginning of the year in order to farm according to her capacity.

Significant differences were found in terms of institutional support by gender which need to be researched into in detail. An important feature observed is that only 17 percent of the women received assistance from an agricultural institution while as many as 42 percent of the men received some assistance (Table 4.8). This explains women's low access to agricultural inputs and limited use, leading to low crop yields, and seems to suggest that policies are usually targeted at men and most women farmers hardly receive any assistance at all. The distribution of agricultural institutional assistance is highly biased against women farmers.

The resource availability and use levels are also different by gender and for the farmers who participated in agricultural programmes and those who did not. The characteristics of the farmers by gender and by participation in agricultural programmes are

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presented in Table 4.9 and 4.10 below. Farmers who have contacts with Agricultural Extension Agents also seem to strive better than those who were not in contact with them.

Out of the 33 farmers who received assistance, only 3 did not apply fertilizer on their farm. This means that the application of fertilizer and adoption of improved farming practices is dependent on whether or not the farmer has agricultural assistance as the assistance makes inputs more readily available to the farmer. The situation is rather serious for women farmers as all the female farmers who participated in agricultural programmes also applied fertilizer on their farms. Those women who did well without assistance are those who had good lands. But the quality of these lands are eroding fast and one questions what the situation would be in the future. El-Hajj and Saade (1992), emphasized that the rate of fertilizer applied to maize should be increased. A close look ought to be taken at the degree to which women are included in agricultural projects of the Ministry of Food and Agriculture, and NGOs such as the SG2000, ADRA and CEDECOM. Leaving out the women in these programmes have serious implications for food security of the fast growing population of Ghana.

Table 4.8 Access To Agricultural Assistance and Other Inputs by the Respondents Presented by Gender

		MALE	FEMALE	Total
Access to Credit	yes	13	7	20
	no	46	39	85
Maize Treatment before storage	yes	45	25	70
	no	14	21	35
Use of herbicide	n/a*	0	1	1
	yes	26	6	32
	no	33	39	72
Assistance from Agric Institution	n/a*	0	1	1
	yes	25	8	33
	no	34	37	71
Application of Fertilizer in Major Season 1998	yes	35	22	57
	no	24	24	48

Source: Calculated from Field Survey, 1998
* n/a means 'not applicable'

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Table 4.9 Characteristics of Farmers By Gender

	Gender of Respondent		
	MALE	FEMALE	Total
Quantity of fertilizer used	1.4	0.9	1.2
Household labour population	3.3	3	3.2
Household population	8	8.3	8.1
Money available for farming last year	428898	182565	320981
Acreage of maize	3.5	2.1	2.9
Maize harvest in mini bags	29.6	12.2	22
Maize consumed in mini bags	4.9	3.6	4.3

Table 4.10 Characteristics of Farmers Who Participated in Agricultural Programmes and Non-Participants

	Participation in Agricultural Programmes		
	Yes	No	Total
Quantity of fertilizer used	2.0	0.8	1.2
Household labour population	3.8	2.8	3.2
Household population	8.9	7.8	8.1
Money available for farming last year	303940	328792	320981
Acreage of maize	3.0	2.9	2.9
Maize harvest in mini bags	26.3	20.0	22.0
Maize consumed in mini bags	5.4	3.8	4.3

Source: Calculated from Field Survey, 1998
Note: A minibag of maize weighs approximately 50 kg.

4.8 Selection of Groups of Farmers.

In this study, groups of farmers are also known as representative farmers. Representative farms are composite or hypothetical farms which are representative of some population. Seini (1985) noted that it is impractical to prepare a farm plan for every farm in a region or even a sample of farmers when the numbers involved are large. Meyer and Zyl (1992) said the first problem is to identify homogeneous groups of farmers (i.e. with similar farm size, yields, and costs per acre). Barnard and Nix (1979) added that there should be homogeneity in at least some of the major resources. Monke and Pearson

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(1990) mentioned some sources of heterogeneity in farms as differences in farm size and differential access to resources. They stated that production estimates can be used as a basis for defining farmer groups. The farmer groups identified for this study fall into groups with homogeneity in input types and amounts, yields, unit cost of production and other resources.

The respondents in the case study area were first divided into two major groups: male and females. A major blow on farmers in Ghana as a result of the SAP was the removal of input subsidies which existed for fertilizer and other farm inputs. The question is 'does the removal of subsidies have significant impact on yields of major food crops'? The answer can be found in analysing the enterprises of fertilizer users and non-users to establish the differences between the performance of their farms. However, it was found out that all the female farmers who were involved in agricultural projects put in place by MOFA, ADRA, SG2000 and CEDECOM used fertilizer. This leads to a clear division of the farmers into another group, namely: those who received agricultural assistance and those who did not receive any agricultural assistance. This distinction will form a basis of policy recommendations on the impact of the SAP on food production.

Significant differences in resource use levels were observed in the survey between those who received agricultural assistance and those who did not, as mentioned earlier. Those who did not receive any assistance had lower fertilizer use levels compared to those who participated in agricultural projects by the Ministry of Food and Agriculture or NGOs. Consequently, it is necessary to find out the performance of food crop enterprises by gender and for those who received agricultural assistance and those who did not, to see if there are any major differences in the performance of their enterprises. There has been a long standing debate as to whether fertilizer subsidies should be re-introduced or not. Policy makers are looking for actual facts from the field with specific recommendations to enable them design policies that will promote the welfare of farmers.

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The groups of farmers earmarked for the base scenarios of the optimization analysis are according to gender and whether the farmers had agricultural assistance (i.e. participated in agricultural projects). They are therefore in two major groups namely: gender and participation in agricultural programme. The farmers were first divided into males and females by grouping, and then by whether or not they participated in agricultural projects.

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Chapter Five
Method of Analysis

5.1 Chapter Overview

This chapter describes the linear programming model which was employed for analysis towards achieving the objectives of the research. It presents the layout of the linear programming model and its components. These components include activities, constraints, resource endowment levels, and consumption requirements that are used in building the model. The chapter starts with the theoretical framework and describes the model specification. To determine the number of labour-days required for each enterprise, cropping calendars are prepared. Crop enterprise budgets which constitute the gross margin analysis are then prepared and presented. The results of the survey was used to derive information needed for building the linear programming model. Finally, the scenarios for simulation are described.

As shown in Chapter Four, both qualitative and quantitative methods of data analysis are used in this study; both methods are necessary as each reveals different aspects of empirical reality. The qualitative description presented in Chapter Four gives the context for interpreting the quantitative data or estimates. As Patton (1990) suggests, one important strategy for conducting evaluation research is to employ multiple methods, measures, researchers and perspectives. The results of the socio-economic analysis become vital in interpreting the results of the quantitative analysis.

5.2 Theoretical Framework

Most models which have analysed issues of concern to this study, have been econometric in nature and have treated only single farm outputs on the production side,

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thereby neglecting the importance of treating multiple crop outputs, as mentioned earlier (Singh and Janakiram, 1986). Farmers in Ghana often engage in mixed and multiple cropping, and linear programming makes such modeling possible.

Linear programming (LP) is a tool for solving optimization problems (Winston, 1995). LP is one of the most frequently and successfully applied mathematical approaches to managerial decisions. It is a model developed to aid the decision maker in determining the optimal allocation of the firm's resources among the alternative products of the firm. The model involves allocating scarce resources, which have alternative uses (competing products and activities) and have economic value, to the products and activities such that profits are maximized; or alternatively, costs are at a minimum (Childress, Gorsky and Witt, 1989). The allocation is done subject to constraints on availability of the resources. It can be applied to agricultural and non-agricultural firms. As Howitt (1995) states, linear programming models are widely used for agricultural economic policy analysis at the sectoral, regional and farm levels.

The farmer has to choose the best crop enterprises and input combinations in order to meet family needs, optimize returns, ensure food security, and which leaves him with sufficient income to meet other financial needs. As farmers have the option of choosing among several crop(s) enterprises, they need to know the combination of enterprises that yield the highest possible net farm returns and the risks associated with making this choice. The small-scale farmer, given his low resource base, will make production decisions and select crops that will ensure his livelihood.

The model has a strong attraction for applied analysis because of its practical approach. LP models are flexible in their response to policy changes and yield variation. The model is suitable for this study as it allows for simulation exercises to show the impact of different policy situations on different farm enterprises. Furthermore, the results provide the farmer with a practical decision making tool. According to Tegene, Huffman and

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Miranowski (1988), the decisions confronting each farmer at a point in time can be represented as a plan for capacity utilization - allocating the available resources among alternative crops.

A limitation of linear programming modelling is the assumption that each additional unit of output requires the same quantity of input, and it does not account for the many instances of diminishing or increasing marginal returns in farm production. Weather variability cannot be appropriately captured, especially in the comparative model. Also, detailed data for thorough recursive models are unavailable in a developing country such as Ghana where farmers do not generally keep records of their farming activities over the years.

5.3 Model Specification

The general model consists of an objective function, a set of constraints and non-negativity restrictions. The model maximizes total gross margins of the various enterprises in each farmer category. The gross margins are discussed further in the subsequent sections. The gross margins are the revenues per acre in the season less the non-fixed costs for the season, since the fixed costs do not change with the level of production during the season.

In any linear programming problem, the decision maker wants to optimize some function of the decision variables; the function to be optimized is called the objective function (Winston, 1995). In this study, agricultural returns (gross margins) are being maximized. The coefficients of the objective function are the contribution of the enterprises to the farmers' profit.

The mathematical specification of the objective function is:

$$Maximize\ Z = \sum_{j=1}^{m} C_j X_j \qquad \text{(Objective Function)} \qquad \ldots \qquad (1)$$

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The maximization of profit is subject to the following constraints:

$$\sum_{j=1}^{m} A_{ij}X_{ij} \leq b_i \qquad \text{(Resource constraint)} \qquad \ldots \quad (2)$$

$$\sum_{k=1}^{n} Q_{jk}X_{jk} \geq d_k \qquad \text{(Food consumption constraint)} \qquad \ldots \quad (3)$$

$$x_j \geq 0 \qquad \text{(Non-negativity constraint)} \qquad \ldots \quad (4)$$

($i = 1, 2, \ldots m; j = 1, 2, \ldots n$)

where:

Z is the sum of gross margins of the various activities in the year,

C_j is the gross margin per acre of the j^{th} activity in the year, and

X_j is the level or acreage of the j^{th} activity in the year.

A_{ij} is the requirement of the i^{th} resource by an acre of the j^{th} activity in the year. These are also known as the technical coefficients.

b_i is the level of the i^{th} resource available for the year.

Q_{jk} is the yield per acre of crop k in the j^{th} activity,

X_{jk} is the acreage of the activity in which crop k appears in the year,

n is the total number of activities in which crop k appears ($n=m$ if all the activities contain crop k), and

d_k is the minimum quantity of crop k required by a household for consumption.

The specification of the objective function is consistent with Howitt (1995), Dittoh (1987), Chaing (1984), McCarl, Kline and Bender, (1990), and Upton (1987), among others. An 'activity' as used here depicts a crop, crop combination, labour hiring, purchase of fertilizer, renting of land, consumption of output, sale of output, purchase of output and

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storage of output.

Hazell and Norton (1986) stated that the problem is to find the farm plan, which is defined by a set of activity levels, that has the largest possible gross margin, but does not violate any of the fixed resource constraints. The detailed information containing the technical coefficients of the above algebraic statements are presented in the LP matrices or tableau. The technical coefficients are the coefficients of the decision variables in the constraints. They reflect the technology used to produce different products. The Right-Hand Side (RHS) (which are the b_j's) represent the quantity of each resource that is available.

The model has five specific constraints:

a. Land Constraint: Land can be used in two different seasons of the year namely: major and minor seasons. Land consists of farmers' own land and land that can be rented.

b. Labour Constraint: consists of family and hired labour.

c. Capital Constraint: The capital constraint is divided into own and borrowed capital. Borrowed capital can be used in either the major or the minor season.

d. Consumption Constraint: depicts the consumption requirements; the minimum amount of output which should be produced in order to have enough food available for household consumption

e. Non-negativity Constraint: A sign restriction is associated with each variable, to ensure negative production is not allowed. At least the number of units of an activity must be zero or positive.

The feasible region will consist of all input combinations that satisfy all the resource and consumption constraints as well as the non-negativity restrictions. The plan that maximizes the farm return also maximizes farm net income and returns to labour for the

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resources used. Winterboer (1973) indicates that the value of the optimal solution is the maximum possible returns the farmer can obtain, given the resource constraints and price relationships assumed in the problem. Farmer-specific data are used to establish the optimum values in this analysis.

The data requirements for the model are:

- available land, available field days
- input requirements and prices
- production costs
- yield levels and prices of output
- output requirements for consumption adequacy

The year 1998 is used as the base year because most of the data were collected in that year.

In a perfect model, each farmer is modelled independently with his or her own unique set of production conditions. However, when production conditions over an area are similar then that area can be treated as one (Meyer and Zyl, 1992). In identifying homogeneous groups of farmers, the sample was first divided into 2 major groups: male farmers and female farmers. The second grouping of farmers is between those who received agricultural assistance and those who did not. Thus, a total of four farmer groups were used for the analysis. Separate LP matrices are built for these four groups of farmers.

Land use, production, yields, prices, costs and gross margins are calculated and determined for each of the four groups of farmers. After selecting the major commodities produced in the area, the task is to assemble a linear programming matrix for the analysis. The food crops which compete for the land and other resources are identified in order to show the alternatives faced by the farmer. Meyer and Zyl assumed the supply of land to be perfectly inelastic thereby making land a constraint. They supplied all other inputs at

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a fixed cost. The model encourages crop diversification, making the results more realistic. It is a dynamic or comparative LP model rather than a recursive one.

5.4 The Gross Margin

In building the LP matrix, the first step is to calculate the gross margins per acre for each enterprise. The gross margin of an activity is the difference between the revenue from that activity and the variable costs incurred in obtaining that revenue, usually expressed in per acre terms (Dent, Harrison, and Woodford, 1986). The general formula for gross margin (π) can be specified as:

$$\pi = \sum_{i=1}^{n} PY - C \qquad i = 1, 2, \ldots n \equiv \text{number of crops on the acre.}$$

where P is the price per unit, Y is the yield in units per acre, and C is the cash cost (or total variable cost) in cedis per acre. This is also known as net agricultural returns. The gross margin can either be entered into the LP matrix directly in the objective function or it can be broken down into its component costs and returns. When the gross margin in entered into the LP matrix as individual components, any cost entered separately is subtracted from the cost that appears under the enterprise in question to avoid double counting. This is explained further in the next chapter. The following paragraphs in this section explain the steps in arriving at the gross margins per acre for each enterprise used in the LP matrix. The enterprise budgets used are presented in Appendix III. The gross margin is included in the model in a disaggregated manner (as costs and returns) to isolate the effects of the different parts of it. This is discussed in detail in Chapter Six.

For the farm, an income statement is usually prepared which itemizes the expenses on one hand and all receipts (credit) on the other. Total expenses are subtracted from total receipts to determine net income. Income consists mainly of sale of farm produce while

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expenses include purchases of agro-chemicals, seed and farm tools, cost of hired labour, cost of renting land, and payment of interest rates on loan. According to Heady and Hopkins (1962), the net cash income is available for family spending and for purchasing inputs for the next cropping season. It could also be invested outside the farm business.

The gross margin is calculated for each crop enterprise and for the four groups of farmers selected. The difficulty noted by Heady and Hopkins is when some expenses apply partly to one enterprise and partly to another. Apportioning the cost among the enterprises becomes a difficult task. This difficulty was overcome by collecting data specific to the crop enterprises. Where this was not possible, the values were disaggregated among the different enterprises to which they apply. The cost of farm tools such as cutlasses, hoes and earth chisels is apportioned among the enterprises. The apportioning is done by taking into consideration which tools were used for the enterprises in question, how many were used per acre in a year, and the gender of the farmer.

5.4.1 Activities

There are 15 crop enterprises under consideration for the male and female farmers, the first two farmer groups, and they are made up of individual crops and crop combinations. The crop enterprises and the notation used for them are presented in Table 5.1. The male and female farmers were found to undertake the same cropping activities. A minor difference was found in that while women often combine garden-eggs with tomatoes, men usually combine it with pepper but both enterprises are undertaken by men and women. Only one of these enterprises was included in the matrices of male and female farmers. In addition, the combination of Maize/Cassava/Cocoyam is more common among women farmers than male farmers. It must be noted that both men and women farmers do undertake all of the crop combinations presented in Table 5.1 with the exception of garden-egg/tomato enterprise. The enterprises were selected based on the

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modal values. Simple data manipulations were performed after Crawford (1982) to select crop mixtures based on the following criteria: (i) importance; and (ii) frequency of occurrence or representativeness of crop mixture among farmers. Crops grown by only one or two farmers were not considered.

Table 5.1 Male and Female Crop Enterprises and Their Abbreviation

No.	Crop Enterprises	Enterprise Abbreviation	Season Grown
1	Major Maize	Maj. M	Major
2	Minor Maize	Min. M	Minor
3	Maize/Cassava	M/Cs	Major/Minor
4	Maize/Plantain	M/Pt	Major/Minor
5	Maize/Cassava/Plantain	M/Cs/Pt	Major/Minor
6	Maize/Cassava/Cocoyam	M/Cs/Cy	Major/Minor
7	Maize/Cassava/Plantain/ Cocoyam	M/Cs/Pt/Cy	Major/Minor
8	Cassava	Cs	Major/Minor
9	Plantain	Pt	Major/Minor
10	Tomatoes	Tm	Major/Minor
11	Pepper	Pp	Major
12	Cowpea	Cowpea	Minor
13	Garden eggs	GE	Major
14	Garden eggs/Pepper	GE/Pp	Major
15	Garden eggs/Tomatoes	GE/Tm	Major

There are considerable differences in the enterprises undertaken when the farmers were divided by participation in agricultural projects and this information is presented in Table 5.2. Farmers who did not participate in agricultural projects engaged in intercropping of more crops on the same field than those who participated. Participating farmers were found to undertake fewer cropping enterprises than non-participating farmers. With the exception of maize/cassava and maize/plantain enterprises, all other enterprises undertaken by those who received agricultural assistance is individual crops. The dash in a cell means the activity is not undertaken.

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Table 5.2 Cropping Enterprises, With and Without Agricultural Assistance

	Crop Enterprises	
	With Agricultural Assistance	Without Agricultural Assistance
1	Major Maize (Maj. M)	Major Maize (Maj. M)
2	Minor Maize (Min. M)	Minor Maize (Min. M)
3	Maize/Cassava (M/Cs)	Maize/Cassava (M/Cs)
4	Maize/Plantain (M/Pt)	Maize/Plantain (M/Pt)
5	— *	Maize/Cassava/Plantain (M/Cs/Pt)
6	— *	Maize/Cassava/Plantain/Cocoyam (M/Cs/Pt/Cy)
7	Cassava (Cs)	Cassava (Cs)
8	Plantain (Pt)	Plantain (Pt)
9	— *	Garden-Eggs/Tomatoes (GE/Tm)
10	Tomatoes (Tm)	Tomatoes (Tm)
11	Pepper (Pp)	Pepper (Pp)
12	Garden-Eggs (GE)	Garden-Eggs (GE)
13	Cowpea	Cowpea

* Not undertaken.

In addition to cropping activities, the model focused on the following activities:

a. labour hiring,

b. capital borrowing,

c. purchase of fertilizer,

d. land rental,

e. selling of produce,

f. storage activities,

g. purchasing of output for consumption, and

h. consumption of output.

Maize can be consumed, sold immediately after harvest, or stored to sell later and for consumption in the lean season. Storage capacity is made available by the farmers constructing some form of crib (local or improved) to store their maize. Cassava, cocoyam

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and plantain are not usually stored and can therefore be consumed or sold for cash. Vegetables are neither stored nor consumed in large quantities but are sold at harvest.

All crop enterprises are not open to the farmer in the minor season due to the short rainfall period. The season is also short in duration.

5.5 Resource Endowment

Land Holding

The resource endowments of the farmers is highly varied, especially according to size of enterprise. Some farmers have almost nothing in terms of land, capital, and even labour. They are farming purely at the subsistence level and living from hand to mouth.

Land is in one category and is all rainfed. Minimal irrigation is done by hand at the early stages for vegetables. The land can either be used in the major season or in the minor cropping season or in both seasons. Cropping the land in both seasons is practiced when the crop(s) grown in the major season do not occupy the land for the whole year. The farmers use some of their own land and also rent land. Land could be rented at 20,000 cedis per acre (¢2,500 = US$1) for a period of one year during the survey period in 1998.

Land is an important resource in agricultural production. Yao and Liu (1998) examined the prospect of raising yields by using more physical inputs in China and found land to be the most important factor of production, followed by fertilizer and then labour input. The results of a study by Kidane (1993) also suggest that land and operating capital are the major limiting factors of production.

Labour

The supply of labour is most critical for land clearing and weeding under crops. Labour for planting and harvesting are important but not so critical since family labour and

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shared labour are often used for these activities. Large crop losses have resulted from failure to weed crops at the recommended time, leading to the crops competing with weeds for the limited soil nutrients.

The farmers use both family and hired labour. Labourers are hired as 'day labour' or on contract[2] It is assumed in this study that all labour is hired on a 'day labour' basis and that family labour and hired labour are perfect substitutes. Family labour is used up first before hired labour is used. Hired labour available is assumed to be one third of total family labour for the season. Labour was hired at a rate of ¢3,000 per day.

Labour for Male and Female Farmers

The average size of a household for male and female farmers is 8 people and the average size of their household labour force is 6 people (2 adults and 4 children who help after school and work full day on Saturdays). A child-day is assumed to be 0.5 labour-day and the adults are counted as a full labour-day. Working after school is counted as 0.3 of a labour-day for three days in a week, making a total of approximately 6 labour-days in a week for the 4 children. The children are supposed to work on the farm on a full-time basis when they are on holidays which now lasts for short periods, especially for the celebration of Christmas and Easter; thus, these short holidays are ignored in counting days worked for children.

The full day's work shall be referred to hereafter as 'labour-days'. The average number of days worked on the farm per week is four days by the two adults. There are therefore 56 labour-days of family labour available on average in each month. It is assumed that when a crop stays in the field, additional labour is hired to weed among the crops besides the labour needed for the activities of the season in question.

[2]Where it is by contract, a number of acres of farm is given to a labourer or group of labourers to clear or weed and a fixed price is paid by the farmer per acre.

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Labour for Farmers with or without Agricultural Assistance

An average size of the household whether participating or non-participation in agricultural programmes is 8 persons. However, the average household labour availability is 6 people for participating farmers and 4 people for non-participating farmers. As such, the total of 56 labour-days of family labour available on average in each month holds for those who received agricultural assistance. For non-participating farmers, it is assumed that there are 2 adults and 2 children. Two adults working an average of 4 days in a week and the children working a total of 3 labour-days in a week results in 44 labour-days in a month.

Farm Tools

It is assumed that tools purchased are used up in a year. Farmers purchase new cutlasses, hoes and earth chisels every year. The amount of tools owned depends on the type of labour used and size of farm. Farmers who used a lot of family labour had more tools than those who hired more labour. Some farmers bought a lot of farm tools for use by hired labour because some of the people hired for work do not have their own tools. The total tool cost was apportioned among the different enterprises based on type of crops that make up the enterprise. Maize and maize enterprises are assumed to consume 60% of the cost of farm tools. Cassava consumes 10 %, plantain 8%, yam 10%, pepper and the other vegetables take 3% each of the total cost of farm tools for the year. This is done on the basis that majority of the land that is cleared is first planted with maize. The cassava, plantain and sometimes the vegetables are inter-cropped with maize, and vegetable enterprises are not usually undertaken on a large scale.

Capital

The farmers have some of their own money which they invest into farming while

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they can also borrow money either from local money lenders or financial institutions. An interest rate of 40 percent per annum is assumed for lending from formal financial institutions. Male farmers can borrow up to 550,000 cedis while women can borrow three hundred thousand cedis (¢300,000) (see Table 5.3). The amount of loan available for farmers who received agricultural assistance and those with no assistance is ¢400,000 and ¢500,000, respectively. Six hundred and fifty thousand cedis (¢650,000) and four hundred and twenty thousand cedis (¢420,000) are available to the male and female farmers, respectively, as owner/operator capital. The capital information is summarized in the table below.

Table 5.3 Capital Distribution by Farmer Type

Type of Capital	Season	Farmer Type			
		Male	Female	Agric. Assistance	No Assistance
Loan	Both	¢550,000	¢300,000	¢400,000	¢500,000
Own Money	Major Season	¢450,000	¢300,000	¢340,000	¢360,000
	Minor Season	¢200,000	¢120,000	¢160,000	¢190,000

The average amount the farmers claimed to have set aside to utilise on their farm expenses was 321,000 cedis (an equivalent of $140[3]) for the major season of 1998. They received an average of 47,000 cedis in the form of loans for the year. This left the farmer with very little income to manage the farm. The situation was worse for the female farmers who received an average of only 15,000 cedis in loans while their male counterparts received 72,000 cedis. The equity-debt ratio was approximately 6:1 for the sample and 4:1 for the women farmers specifically. Men therefore, have more access to credit than women.

[3]Exchange rate used is $1 to ¢2500.

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Loan/Credit

Input costs have risen sharply as a result of the removal of subsidies which was part of the SAP package, thereby increasing the total cash outlay of the farmer. Credit is the most constraining resource reported by the farmers. Many farmers have complained that they have the land but do not have enough money to develop it into the type of farm they want or the size they want. The most important problem identified by the farmers is financial in nature, with over 80 percent saying credit and finance was their major problem.

Farmers expressed the need for policies to increase their eligibility to obtain credit by reducing the demand for collateral security from them. Credit institutions are said to demand collateral securities such as buildings, capital reserves and long term assets, which the farmers do not have. The farm itself should be used as a basis for granting loans to small-scale farmers. In the Central Region of Ghana, only 19 percent of the farmers obtained loans from formal institutions for their farming activities in 1998. Eighty-one percent never received a loan for farming. Majority of those who never received a loan for varying reasons, never applied for loans. Some of the reasons given for not applying for a loan include the following:

i. I do not know anybody/ I have no contacts,

ii. The banks are not honest and I do not trust them,

iii. I am afraid to apply,

iv. I do not know that women can also apply for a loan.

Some poor farmers have confirmed being cheated when they applied for loans at the bank. The ways in which the farmers were cheated include being asked to pay a percentage of the loan to the bank manager even though they will eventually be required to pay the full loan with interest.

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Seed

Farmers buy seed for maize, pepper, tomatoes and garden eggs seeds, as well as plantain suckers and yam heads. They also use seed from the previous harvest from their farm (they select the best and store for planting in the next season). They usually do not buy cassava sticks unless they plant on a large scale, when their sticks have dried out after a dry season, or when they have not harvested cassava in the near past. Cocoyam plants grow on most lands voluntarily at no cost to the farmer. They only need to transplant some of the plants for spacing. On a per acre basis, when the crops are intercropped, the amount of seed used is less than the amount required when the crop is grown as an individual crop. The prices of seed and fertilizer observed from the survey are presented in Table 5.4.

Table 5.4 Prices of Inputs Used by the Respondents

Input	*Quantity Used Per Acre **	*Price Per Unit (cedis)*	*Total Cost Per Acre*
Fertilizer - Male	2.1 kg	25000	52500
Female	1.2 kg	25000	30000
Agric. Assistance	3.1	25000	77500
Without Assistance	1.2	25000	30000
Maize seed (kilos)	5 kg	3000	15000
Plantain Suckers - mixed crop	600 units	150	90000
Cassava Stick (headloads)	6 units	2500	15000
Cocoyam Suckers	Germinates Voluntarily	0	0
Tomatoes Seed (containers)	1 units	20000	20000
Pepper Seed (cups)	4 units	5000	20000
Garden eggs Seed	4 units	5000	20000

Source: Calculated from Field Survey, 1998
*The units of measurements are varied and some have no common weights and standard weights are not yet available.

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Output

The problem of diverting labour from food to cash crop production and selling food that ought to have been retained for family subsistence, can lead to a worsened household nutrition in African countries such as Tanzania, and has attracted the attention of external organisations (Tibaijuka, 1994). The way of guarding against this problem, Tibaijuka suggested, is to have family consumption restrictions, hence the inclusion of the output constraints. In this study, instead of output constraints, consumption constraints are included which allows the farmer the option of either producing or purchasing food for home consumption.

5.6 Cropping Calendars

Cropping calendars were prepared to determine the labour requirements for each enterprise under consideration. Cropping calendars are the same for male and female farmers and for participating and non-participating farmers in agricultural programmes. The calendars show the time needed for land preparation, planting, fertilizing of crops, weeding and harvesting of crops. They also show the number of labour-days required for each activity in the calendar, leading to the calculation of total labour requirements per enterprise. The cropping calendars are presented in tables in Appendix II. The total labour requirement without fertilizing was used for the farmer groups without agricultural assistance.

5.7 Crop Enterprise Budgets

Crop enterprise budgets were prepared for each crop enterprise (i.e. crop or crop combination) using 1998 purchase and sale prices. The enterprise budgets contain information on the costs of production, input and output prices, yields, and input use levels.

The crop enterprise budgets are prepared on per acre basis and are presented in

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Appendix Table II. The budgets represent the economic environment where decisions are made. Income generated is mainly from sale of produce after accounting for consumption, with the exception of vegetables where consumption is not in significant quantities. Variable cost calculations include land rental and tool costs. The period for which land is rented depends on the agreement between the landowner and the tenant (ie farmer). However, land is usually rented for a period of one year or until the cropping cycle is completed.

Prices are exogenous as the farmer is considered as a price taker. Women farmers who produce kenkey, a meal produced from maize, purchase their own maize at the prevailing prices and process the maize into kenkey. The income from kenkey production is classified under off-farm income. This classification makes it possible to use uniform prices in the analysis without having to include two activities for the two different prices. Prices also vary by the period of sale. The prices of farm products in Ghana are low during the peak season and high during the lean season; stored maize is more expensive than maize sold just after harvest. Products such as plantain can be harvested throughout the year, but less quantities are harvested during the dry season. Vegetables have both seasonal and spatial price differences. They are cheap in vegetable-producing areas and expensive in other locations. Average prices, based on the survey, are used in this study (see Table 5.5).

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Table 5.5 Average Prices of Output of the Crops Under Consideration

Crop	*Price* Per Unit (Cedis)	
	Average	Stored Maize
Major Season Maize (Mini-bags)	35000	45000
Minor Season Maize (Mini-bags)	38000	50000
Cassava (Mini-bags)	22000	
Plantain (Bunches)	4000	
Cocoyam (Mini-bags)	15000	
Tomatoes (Crates)	24000	
Cowpea (Mini-bags)	60000	
Pepper (Mini-bags)	15000	
Garden eggs (Mini-bags)	13000	

Source: Calculated from Field Survey, 1998

Labour requirements and fertilizer costs are accounted for separately as they enter the LP model separately in showing their levels of use. The main aim of the crop enterprise budgets is to estimate the gross margins per acre, which are summarized in Table 5.6 though 5.9 for all the four farmer types. Yields were multiplied by prices to obtain gross revenues.

The gross margin calculations for male farmers in Table 5.6 show that enterprises with crop combinations have higher gross margins than those with individual crops. This finding is consistent with Dittoh and Ogunfowora (1987) in their study of the Ejiba and Dogongari Irrigation Schemes in Nigeria. The vegetable enterprises have the highest gross margins; the Garden-eggs/Tomatoes (GE/Tm) enterprise is followed by Garden-eggs/Pepper (GE/Pp). Individually cultivated cassava has the lowest gross margin. For the staple food crop enterprises, Maize/Cassava/Plantain/Cocoyam (M/Cs/Pt/Cy) recorded the highest gross margin. The female enterprises follow a similar trend except with lower gross margins, mainly as a result of lower yield levels. The output level and price of the product are the two most important determinants of the gross margin.

Gross margin calculations for enterprises of farmers with and without agricultural

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assistance are shown in Table 5.8 and 5.9, respectively. For farmers with agricultural assistance, the highest gross margin is from the garden-egg enterprise, followed by the tomato enterprise (Table 5.8). The maize/cassava and maize/plantain enterprises are next in terms of the gross margin they generate. It is interesting to note that the maize/plantain enterprise had the largest total variable cost. The high cost can be due to the fact that it includes costs from last year's plantain which is harvested in the current year. Cowpea and minor season maize generated the least gross margin.

Farmers with no agricultural assistance had the garden-egg/tomato enterprise producing the highest gross margin, followed by the individually cultivated garden-egg enterprise, and then the tomato enterprise (Table 5.9). Maize/cassava/plantain/cocoyam is third in level of gross margin. Minor season maize had a very low gross margin but the lowest is from the cowpea enterprise.

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Table 5.6 Gross Margin Calculations for Male Farmers

Enterprise	Lab. Days Required	Lab. Cost	Non-Lab. Cash Expenses	Total Variable Cost	Crop	Output by Crop	Output Price/ Unit	Total Revenue Per Acre	Gross Margin Per Acre
	Labour-days	Cedis	Cedis	Cedis	-*	-**	Cedis	Cedis	Cedis
Major Maize	46	138000	42792	180792	M	15	35000	525000	344208
Minor Maize	44	132000	38292	170292	M	11.5	38000	437000	266708
M/Cs	88	264000	107832	371832	M Cs	12.5 17	35000 22000	811500	439668
M/Pt	85	255000	256824	511824	M Pt	12.5 220	35000 4000	1317500	805676
M/Cs/Pt	112	336000	287832	623832	M Cs Pt	12.5 17 150	35000 22000 4000	1411500	787668
M/Cs/Cy	92	276000	107832	383832	M Cs Cy	12.5 17 12	35000 22000 15000	991500	607668
M/Cs/Pt/Cy	117	351000	287832	638832	M Cs Pt Cy	12.5 17 150 12	35000 22000 4000 15000	1591500	952668
Cs	66	198000	40080	238080	Cs	20	22000	440000	201920
Pt	65	195000	188064	383064	Pt	240	4000	960000	576936
Pp	48	144000	28262	172262	Pp	24	15000	360000	187738
Cowpea	43	129000	22510	151510	Cowpea	5	60000	300000	148490
Tm	46	138000	48266	186266	Tm	45	24000	1080000	893734
GE	47	141000	63266	204266	GE	160	13000	2080000	1875734
GE/Pp	67	201000	83266	284266	GE Pp	115 18	13000 15000	1765000	1480734

Source: Calculated from Field Survey 1998
* See Table 5.1 and key below for definitions
** Output measurements vary by crop.

Key: **(M)** = Maize; **(M/Cs)** = Maize/Cassava; **(M/Pt)** = Maize/Plantain; **(M/Cs/Pt)** = Maize/Cassava/Plantain; **(M/Cs/Cy)** = Maize/Cassava/Cocoyam; **(M/Cs/Pt/Cy)** = Maize/Cassava/Cocoyam/Plantain; **(Cs)** = Cassava; **(Pt)** = Plantain; **(Pp)** = Pepper; **(Tm)** = Tomatoes; **(GE)** = Garden-eggs; **(GE/Pp)** = Garden-eggs/Pepper

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Table 5.7 Gross Margin Calculations for Female Farmers

Enterprise	Lab. Days Required	Lab. Cost	Non-Lab. Cash Expenses	Total Cost	Crop	Output by Crop	Output Price/ Unit	Total Revenue Per Acre	Gross Margin Per Acre
	Labour-days	Cedis	Cedis	Cedis	-*	-**	Cedis	Cedis	Cedis
Major Maize	46	138000	44715	182715	M	13.5	35000	472500	289785
Minor Maize	44	123000	48715	171715	M	10.5	38000	399000	227285
M/Cs	88	264000	84205	348205	M Cs	11.5 18	35000 22000	798500	450295
M/Pt	85	255000	193307	448307	M Pt	11.5 210	35000 4000	1242500	794193
M/Cs/Pt	112	336000	264205	600205	M Cs Pt	11.5 18 160	35000 22000 4000	1438500	838295
M/Cs/Cy	92	276000	84205	360205	M Cs Cy	11.5 18 18	35000 22000 15000	1068500	708295
M/Cs/Pt/Cy	117	351000	264205	615205	M Cs Pt Cy	11.5 18 160 18	35000 22000 4000 15000	1708500	1093295
Cs	66	198000	38980	236980	Cs	23	22000	506000	269020
Pt	65	195000	185920	380920	Pt	230	4000	920000	539080
Pp	48	144000	28847	172847	Pp	34	15000	510000	337153
Cowpea	43	129000	21850	150850	Cowpea	6	60000	360000	209150
Tm	46	138000	49296	187296	Tm	56	24000	1344000	1156704
GE	47	141000	64296	205296	GE	60	13000	780000	574704
GE/Pp	67	201000	84296	285296	GE Pp	52 25	13000 15000	1051000	765704

Source: Calculated from Field Survey 1998

* See Table 5.1 and key below for definitions

** Output measurements vary by crop.

Key: **(M)** = Maize; **(M/Cs)** = Maize/Cassava; **(M/Pt)** = Maize/Plantain; **(M/Cs/Pt)** = Maize/Cassava/Plantain; **(M/Cs/Cy)** = Maize/Cassava/Cocoyam; **(M/Cs/Pt/Cy)** = Maize/Cassava/Cocoyam/Plantain; **(Cs)** = Cassava; **(Pt)** = Plantain; **(Pp)** = Pepper; **(Tm)** = Tomatoes; **(GE)** = Garden-eggs; **(GE/Pp)** = Garden-eggs/Pepper

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Table 5.8 Gross Margin Calculations for Farmers With Agricultural Assistance

Enterprise	Lab. Days Required	Lab. Cost	Non-Lab. Cash Expenses	Total Variable Cost	Crop	Output By Crop	Output Price/ Unit	Total Revenue Per Acre	Gross Margin Per Acre
	Labour-days	Cedis	Cedis	Cedis	-*	-**	Cedis	Cedis	Cedis
Major Maize	46	138000	53632	191632	M	13.5	35000	472500	280868
Minor Maize	44	132000	47132	179132	M	10	38000	380000	200868
M/Cs	88	264000	109472	373472	M Cs	12 18	35000 22000	816000	442528
M/Pt	85	255000	258304	513304	M Pt	12 135	35000 4000	960000	446696
Cs	66	198000	41680	239680	Cs	23	22000	506000	266320
Pt	65	195000	189344	384344	Pt	150	4000	600000	215656
Pp	48	144000	31502	175502	Pp	40	15000	600000	424498
Cowpea	43	129000	22946	151946	Cowpea	6	60000	360000	208054
Tm	46	138000	53586	191586	Tm	42	24000	1008000	816414
GE	47	141000	68586	209586	GE	145	13000	1885000	1675414

Source: Calculated from Field Survey 1998

* See Table 5.1 and key below for definitions

** Output measurements vary by crop.

Key: **(M)** = Maize; **(M/Cs)** = Maize/Cassava; **(M/Pt)** = Maize/Plantain; **(Cs)** = Cassava; **(Pt)** = Plantain; **(Pp)** = Pepper; **(Tm)** = Tomatoes; **(GE)** = Garden-eggs

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Table 5.9 Gross Margin Calculations for Farmers Without Agricultural Assistance

Enterprise	Lab. Days Required	Lab. Cost	Non-Lab. Cash Expenses	Total Variable Cost	Crop	Output by Crop	Output Price/ Unit	Total Revenue Per Acre	Gross Margin Per Acre
	Labour-days	Cedis	Cedis	Cedis	-*	-**	Cedis	Cedis	Cedis
Major Maize	46	138000	44137	182137	M	11.5	35000	402500	220363
Minor Maize	44	132000	39137	171137	M	8.5	38000	323000	151863
M/Cs					M	10	35000		
	88	264000	83077	347077	Cs	17	22000	724000	376923
M/Pt					M	10	35000		
	85	255000	232289	487289	Pt	215	4000	1210000	722711
M/Cs/Pt					M	10	35000		
					Cs	17	22000		
	112	336000	263077	599077	Pt	154	4000	1340000	740923
M/Cs/Pt/Cy					M	10	35000		
					Cs	17	22000		
					Pt	154	4000		
	117	351000	263077	614077	Cy	12.5	15000	1527500	913423
Cs	66	198000	37880	235880	Cs	24	22000	528000	292120
Pt	65	195000	186304	381304	Pt	225	4000	900000	518696
Pp	48	144000	28682	172682	Pp	45	15000	675000	502318
Cowpea	43	129000	21552	150552	Cowpea	4	60000	240000	89448
Tm	46	138000	49076	187076	Tm	53	24000	1272000	1084924
GE	47	141000	64076	205076	GE	120	13000	1560000	1354924
GE/Tm					GE	95	13000		
	66	198000	84076	282076	Tm	29	24000	1931000	1648924

Source: Calculated from Field Survey 1998
* See Table 5.1 and key below for definitions
** Output measurements vary by crop.

Key: **(M)** = Maize; **(M/Cs)** = Maize/Cassava; **(M/Pt)** = Maize/Plantain; **(M/Cs/Pt)** = Maize/Cassava/Plantain; **(M/Cs/Pt/Cy)** = Maize/Cassava/Cocoyam/Plantain; **(Cs)** = Cassava; **(Pt)** = Plantain; **(Pp)** = Pepper; **(Tm)** = Tomatoes; **(GE)** = Garden-eggs; **(GE/Tm)** = Garden-eggs/Tomatoes

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5.8 Linear Programming Matrices

The objective of the linear programming analysis is to determine the crop enterprises to undertake, ensuring the production of sufficient food for household consumption while maximizing total farm gross margin. The linear programming matrix was built for a period of one year, with two seasons: the major season and the minor season, because farmers can produce maize both in the major season and in the minor season. Crops that are intercropped such as maize/cassava are cultivated in the major season so that the maize is harvested but the cassava continues to occupy the land. Cowpea is another minor season crop. However, some of the farmers do not cultivate new plots in the minor season, hence many crop enterprises remain in the major season option. In the minor season, farms are usually smaller and less capital input is required. According to Hazell and Norton (1986), seasonal patterns in resource use should not be ignored in constructing a linear programming model. This is to avoid the problem of obtaining unrealistic solutions by which more resources are required in some periods than are available.

The objective function contains the values of costs and returns for each enterprise, as well as land hiring and capital borrowing costs which apply to all enterprises. The objective function values in the crop activities refer to the total variable cost less labour hiring costs, cost of purchasing fertilizer, and land rental charges for producing one acre of the crop enterprise. Thus, they enter as negative values. Labour hiring, fertilizer purchase, land rental and interest on capital are entered as individual activities. The returns for the crop are accounted for in the selling activities where revenue comes into the enterprise. Part of the crop is sold and the other part consumed. Entering the costs and returns separately in a disaggregated fashion disentangles the results and provides clear insights into the aspects of the model that are causing the changes. Sensitivity analysis is made easy as the changes in the parameters can be easily identified and their marginal effects on the model are known.

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A notable feature of nearly all developing countries is that most agricultural households produce a significant portion of the staple foods that they consume (Renkow, 1990; Singh, Squire, and Strauss, 1986). The tendency to produce food crops in large surpluses for sale is also on the increase. The way of guarding against this problem of diverting labour from food to cash crop production and selling food that ought to have been retained for family subsistence (at times leading to a worsened household nutrition) is to have a family consumption restriction (Tibaijuka, 1994), hence the inclusion of the output constraints in the model. The maximization of farm income may represent a reasonable objective for commercial farmers, especially in advanced countries. For the small-scale farmers in developing countries, a more primary goal for farming is often to provide their families with adequate food. Such farmers face rural markets that are usually incomplete, exploitable or unreliable, and trading cash crops for food is rarely a sound strategy for ensuring survival (Hazell and Norton, 1986). As a result, it is appropriate to ensure that the farmer produces enough to cater for the food needs of the home. The marketable surplus is then sold to generate income. The program produces the optimal choice of enterprises to be undertaken to first meet the food demand objectives of the farmer and then to generate income.

A consumption constraint is incorporated in the LP model by adding lower bound constraints on the production of required food crops, which are mainly maize, cassava and plantain. These rows are called consumption balance rows, indicating the amount required for consumption on the right-hand-side. The consumption rows are summarized in Table 5.10 for an average family for one year. This means that the farmer can consume either maize from the major season, minor season, store major season maize, store minor season maize or maize purchased from another source rather than own production. These values have taken gifts to friends and other extended family members into consideration.

The consumption requirement is met first by the feasible solution and the remaining

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surplus used by the selling activity, depending on the profitability of the enterprise(s) in which these crops appear. This is accounted for in the objective function by reducing it by the amount consumed.

Tibaijuka noted that, to meet cash requirement obligations, the farmer is expected to produce a certain minimum. Beyond family subsistence, there must be incentives for further production.

Table 5.10 Values of Consumption Requirements for Farm Households*

Crop	Description	RHS	Units
Maize- Major	Output from major season maize	4	Mini-bags
Maize -Minor	Output from minor season maize	3.5	Mini-bags
Major Stored Maize	Stored major season maize	2	Mini-bags
Minor Stored Maize	Stored minor season maize	3	Mini-bags
Cassava	Cassava	10	Mini-bags
Plantain	Plantain	140	Bundles

Source: Determined from Field Survey, 1998
*Requirements for one year

Land is assumed to be homogeneous in the model. Thus, it does not explain the differences in yield by soil type. Land can be rented both in the major and minor seasons at a cost of 20,000 cedis.

Capital is borrowed at the beginning of the year and used throughout the two cropping seasons. The owners' capital was also divided between major and minor seasons. The allocation of the cost of tools is discussed in Chapter Four.

5.9 Scenarios for Simulation

To complete the interpretation of the farm plan developed through linear programming requires investigation of the stability of the plan under alternate conditions (Beneke and Winterboer, 1973). Sensitivity analysis is used to determine the stability of the

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optimal solution by varying the values of the limiting resources (Kidane, 1993).

The analysis considers how changes in some of the resource levels and prices alter the profitability of the farm enterprises and the food security situation of the groups of farmers. The farmer needs to decide how much of each crop to cultivate in each season, knowing the amount of resources available to him.

A major issue at stake is to see how agricultural policies affect male and female farmers. As mentioned earlier, assistance by agricultural institutions (including NGOs) has been mostly directed to male farmers. The scenarios for the simulation analysis are discussed below.

The first scenario was an increase in the amount of rented land. This is necessary as the farmers in the research area have the opportunity to increase rented land. Female farmers particularly have smaller land holdings and it is vital to find out what the performance of their farm enterprises would be with an increase in rented land.

The second scenario was an increase in hired labour. Labour is crucial for land preparation, weeding and harvesting as well as for transporting farm produce.

The third scenario for simulation is an increase in the amount of credit available. Credit available to the farmers is highly limited and could limit the amount of crop enterprises that are undertaken, labour hiring activities and purchase of inputs. This scenario makes more money available for farm expenditure. As observed earlier, maize depends highly on the amount of money available for farming purposes.

The fourth simulation involves an assumption of a selective subsidy on fertilizer which results in an increase in maize yield. The relevance of increasing maize yield has been an issue of much discussion for some time. With the SAP and removal of subsidies on inputs such as fertilizer, many farmers reduced the quantities purchased while others have stopped its use completely. Increased yields depend on improved farm management practices as well as increase in the use of fertilizers.

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Chapter Six

Optimization Analysis and Results

6.1 Introduction

The first part of this chapter describes the base scenarios of the linear programming analysis. The details of the linear programming matrices were outlined in the previous chapter. The models for the base scenarios were run and the results for the different farmer groups are presented here. The output for the male and female farmers are reported together in order to see the direct gender differences and performance of their farm enterprises. After that, results for farmers with and without agricultural assistance are presented together to determine the impact of extending agricultural assistance to farmers in the region under consideration.

To assess the representativeness of the model formulations, the model was validated by comparing the models' solutions with observed mean values of key variables. This indicates whether the results are realistic and whether they represent what happens in real life situation in the study area. A sensitivity analysis based on varying input and output prices, and credit policies of the Ghanaian government was carried out and the results are reported at the end of this chapter.

6.2 Base Scenarios

Four base scenarios were estimated and are summarized in Table 6.1 below. The base scenarios for the four situations were male farmers, female farmers, farmers who received agricultural assistance (those who participated in agricultural programmes of the Ministry of Food and Agriculture and other NGOs) and those who did not receive agricultural assistance. Male and female farmers here embody the total of all men and all women farmers in the study area.

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The LP matrices for each scenario were entered into a Quattro Pro spreadsheet for the optimization analysis (i.e. for solving) and the base scenario was analysed for the four situations mentioned above. The objective of the analysis is to choose enterprises that maximize farm returns while ensuring food security at the household level. Some of the result were further examined to determine the amount of revenue generated by each crop.

Table 6.1 Scenarios in the Base Model

Number	Scenario Name	Description
1	Male Farmers	Representing what happens among male farmers in the region.
2	Female Farmers	Encompassing all female farmers in the area under consideration.
3	Farmers who received agricultural assistance	Farmers who were part of agricultural assistance programmes of the Ministry of Food and Agriculture and other NGOs such as ADRA, SG2000 and CEDECOM.
4	Farmers who did not receive agricultural assistance	Farmers who were not part of any agricultural assistance programme.

6.3 Linear Programming Results for Male and Female Farmers

The model for male farmers was designed to represent a typical farm for the men in the region. It shows the crop enterprises they engage in, the amount of labour needed for the various enterprises, fertilizer and other input use, the output levels of the different crops, the capital availability for the farmer, and the amount he is allowed to borrow. Five acres of owner's land was used for male farmers and up to 3 acres of land could be rented.

For female farmers, owners' land was 3 acres and up to 2 acres of land could be rented. The resource levels are based on the survey of the 1998 cropping year, secondary

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data from the Ministry of Food and Agriculture and Agricultural Extension staff, as well as what typically happens in the area. The model was run and the results are reported below. These levels are reflections of reality.

The model allowed for the production of any of the crop enterprises. It also allowed for the consumption of food either from own production or from purchased products to meet the consumption requirements. The production strategies selected for the optimal farm plan are tabulated and discussed in the sections below.

The results of the optimization analysis for male and female farmers are presented in this section and their differences are discussed. Table 6.2 presents the optimal income for male farmers, the crop enterprises that entered the farm plan, and the amount of each crop enterprise undertaken. The optimal income level recorded about 9.4 million cedis (approximately US$3,756). The exchange rate was $1 to 2500 cedis at the time.

The desired farm plan for female farmers is presented in Tables 6.3. The optimal income level in the solution of the LP analysis for female farmers was about 4.4 million cedis (approximately US$1,763). Only major maize, minor maize, maize/cassava/plantain/cocoyam and tomatoes enterprises entered the farm plan in the solution (Table 6.3). As in the case of male farmers, the total restriction of vegetable production was exhausted in vegetable production.

The optimal level of income for male farmers is more than double that of the women. Women have lower land available to them, less credit facilities, and have lower output levels in most crops. Despite all these constraints, they face the same labour requirements and cost as their male counterparts, and also face the same input and output prices.

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Table 6.2 Optimal Enterprises for Male Farmers

Solution	Crop Enterprises in Solution	Level (Acres)
Optimal Income Level	9,388,682 cedis	
	Major Season Maize	2.1
	Minor Season Maize	5
	Maize/Cassava/Plantain/Cocoyam (M/Cs/Pt/Cy)	1
	Garden-eggs (GE)	3

Table 6.3 Optimal Farm Plan for Female Farmers

Solution	Crop Enterprises in Solution	Level (Acres)
Optimal Income Level	4,408,808 cedis	
	Major Season Maize	1.3
	Minor Season Maize	3.3
	Maize/Cassava/Plantain/Cocoyam (M/Cs/Pt/Cy)	0.9
	Tomatoes	2

The models were first run with no restrictions in the production of any enterprise. The results were observed, but it was realized that almost all the land was being used in vegetable production and other food crops were produced only to meet food availability requirements. Vegetable production was thereby restricted to 3 acres for male farmers and 2 acres for female farmers as that was more representative of the actual practice on the farm. Though this resulted in a reduction of the optimal income levels, it made the results more realistic as it reflects what happens in real life in the study area.

From the solution, more land was devoted to the production of maize in the minor

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season than in the major season. All the acres allocated for the production of vegetables were exhausted in the male and female farm plans as vegetables have proven to be very profitable. This is consistent with the results of the gross margin analysis in Chapter Five.

Staple crops other than maize, (i.e. cassava and plantain) did not enter the optimal farm plan much beyond what is needed to meet consumption requirements. This could mean that either the enterprises in which these crops appear are not profitable for the farmers to engage in on a large scale, or that farmers were not using the resources efficiently in their production activities. However, other socio-cultural factors that determine what the farmer produces have to be considered before further conclusions are drawn. Farmers refer to maize as their traditional crop and some of the respondents called it 'good mother', as discussed in chapter 5. The availability of maize makes the farmers food secure. Consequently, farmers will continue to produce maize even when it is not profitable to do so as producing maize and other staple crops assures them of food security.

6.3.1 Resource Use

Land

The availability and use of land, labour, and capital are presented in this section. Land usage for male and female farmers are presented in Table 6.4. In both the major and the minor seasons, all the land that was available as farmers own land was used up by both male and female farmers. Male farmers did not utilize all the land available for renting.

The shadow prices, which are known as marginal value product (MVP) show the effect of having one more unit of the resource on the optimal income. For resources that are constraining, shadow prices show the increase in the optimal income as a result of making one unit of the resource available. The shadow prices for own land in both seasons is ¢60,914 and about ¢300,000 for male and female farmers, respectively. Rented land is constraining for women farmers and has a slightly higher shadow price in the major season

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than in the minor (Table 6.4). It can therefore be said that making more land available to the farmer as own land will result in an increase in optimal income. The high shadow price of land for female farmers indicates that at the margin, land would produce more value for female farmers.

Table 6.4 Land Use Patterns of Male and Female Farmers

Activity Type		Amount Available	Amount Used	Slack	Shadow Price
Male Farmers					
Land: major season	- Own	5	5	0	60914
	- Rented	3	2.1	0.9	0
Land: minor season	- Own	5	5	0	60914
	- Rented	3	1.9	1.1	0
Female Farmers					
Land: major season	- Own	3	3	0	305950
	- Rented	2	2	0	239283
Land: minor season	- Own	3	3	0	287617
	- Rented	2	2	0	220950

Capital

Capital is constraining because the optimization analysis shows that all the money available for farming in the major and minor seasons was exhausted and the farmers borrowed the maximum amount made available to them for borrowing in the model. More of the borrowed capital was used in the major season than in the minor (Table 6.5).

The major season is the main season for farming activities. Land clearing and plans for the year are made at the beginning of the year. Capital is borrowed at the beginning of the year but can be used in the major or minor season as needed. Farmers have to repay

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the principal with interest for all borrowed money.

Table 6.5 Capital Availability and Use for Male and Female Farmers

Activity Type		Amount Available (cedis)	Amount Used (cedis)
Male Farmers			
Capital: Own:	Major season	450000	450000
	Minor Season	200000	200000
Borrowed	- Used in Major	550000	361906
	- Used in Minor		188094
Capital Repayment		Total amount borrowed	550000
Female Farmers			
Capital: Own:	- Major season	300000	300000
	- Minor Season	120000	120000
Borrowed	- Used in Major	300000	159051
	- Used in Minor		140948
Capital Repayment		Total amount borrowed	300000

Labour

Labour availability and use are outlined in Tables 6.6 and 6.7. For male farmers, family labour is constraining in the periods from March to October. During these time periods, an increase in the amount of family labour available will result in an increase in the optimal value of the objective function. The shadow prices are shown in Table 6.6. Additional labour in the January/February and November/December periods would not add any extra value to the optimal value of the objective function. No labour was hired in March/April and May/June periods even though all the family labour was used up. Making one labour-day of hired labour available in the periods of July/August and September/October will increase the value of the optimal value of the objective function by

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9,137 cedis.

Labour is not a limiting resource for female farmers in any of the months (Table 6.7). Due to the low levels of land and capital available to them, they are probably unable to produce a lot which will necessitate them to use more labour. This would be made more evident in the sensitivity analysis.

Table 6.6 Labour Use For Male Farmers

Month	Available Labour-days		Use		Slack		Shadow Price	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Jan/Feb	112	37	22	0	90	37	0	0
Mar/Apr	112	37	112	0	0	37	8495	0
May/June	112	37	112	0	0	37	4049	0
July/Aug	112	37	112	5	0	32	9137	0
Sept/Oct	112	37	112	36	0	1	9137	0
Nov/Dec	112	37	59	0	53	37	0	0

Table 6.7 Labour Use for Female Farmers

Month	Available		Use		Slack		Shadow Price	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Jan/Feb	112	37	17	0	95	37	0	0
Mar/Apr	112	37	77	0	35	37	0	0
May/June	112	37	86	0	26	37	0	0
July/Aug	112	37	78	0	34	37	0	0
Sept/Oct	112	37	97	0	15	37	0	0
Nov/Dec	112	37	39	0	73	37	0	0

6.3.2 Fertilizer Usage

Although the quantity of fertilizer used by the women was lower than that of their men counterparts on the whole, on per acre basis for the women who used fertilizer, they

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used slightly higher levels. Therefore, the technical coefficients for fertilizer in the LP model are higher for female farmers than for male farmers. From the results, male farmers purchased 4 bags per acre of fertilizer in the major season and 3.5 bags of it in the minor season. Female farmers purchased 3 bags per acre of fertilizer in the major season and 2.6 bags in the minor season.

6.3.3 Revenue Generated From Different Crops

The amounts produced and sold are estimated and shown in Table 6.8 for male farmers in order to consider the revenue generated for each crop separately if the farm plan in the solution is followed. The highest revenue was obtained from the garden-eggs enterprise. Minor season maize produced the next highest revenue, followed by major season maize. The revenue from cassava, plantain and cocoyam are not considerable. When a lot of garden-eggs is produced, it will result in a decrease in prices.

Revenue from the various crops for the female farmers are presented in Table 6.9. Tomatoes generated the highest revenue among all the crops with total revenue of 2.7 million cedis, followed by maize with total revenue of 2.2 million cedis. No plantain was sold in the female farm plan, implying that plantain was not produced beyond the minimum consumption requirement. The female farmers only produced enough plantain for home consumption. Part of the major season maize was stored and sold later during the year at a higher price. The 9.73 mini-bags of maize in Table 6.9 refers to major season maize which was sold immediately after harvest and the 10.6 mini-bags was stored from major season production. The revenue per acre presented for major maize is the total revenue for the enterprise.

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Table 6.8 Male Farmers' Revenue From Various Crops

Crop	Measurement	Amount Produced*	Quantity Sold	Price Per Unit	Revenue per Crop (¢)
Maize - Major	Mini-bags	43.8	37.8	35000	1701000
Maize - Minor	Mini-bags	57.0	50.5	45000	2272500
Cassava	Mini-bags	16.6	6.6	22000	145200
Plantain	Bunches	146.1	6.1	4500	27450
Cocoyam	Mini-bags	11.7	11.7	15000	175500
Garden-eggs	Mini-bags	480.0	480	13000	6240000

* The amount that would be produced if farm plan is followed.

Table 6.9 Female Farmers' Revenue From Various Crops

Crop	Measurement	Amount Produced*	Quantity Sold	Price Per Unit (cedis)	Revenue per Crop (cedis)
Maize - Major	Mini-bags	26.3	9.73	35000	817550
Stored maize			10.6	45000	
Maize - Minor	Mini-bags	34.1	27.6	50000	1380000
Cassava	Mini-bags	15.8	5.75	22000	126500
Plantain	Bunches	140	0	4500	0
Cocoyam	Mini-bags	15.8	15.8	15000	237000
Tomatoes	Crates	112.0	112	24000	2688000

* The amount that would be produced if farm plan is followed.

Below are the shadow prices of crop enterprises which did not enter the optimal solution (Table 6.10). The shadow prices reported here are the cost of forcing one acre of the enterprise into the farm plan, hence they are presented with negative signs. It will cost the farmer over 1.6 million cedis to force one acre of pepper into the farm plan, and about ¢945,178 and ¢533,213 for tomatoes and garden-eggs/pepper enterprises, respectively. The cost of ensuring that the staple food crop enterprises (i.e. those containing maize, cassava, plantain, cocoyam) form part of the solution are not critical, as portrayed by the low shadow prices of the enterprises in which these crops appear (see Table 6.10).

Table 6.11 shows the cost of forcing one acre of the enterprises that did not enter the farm plan for female farmers. The cassava enterprise is the most undesirable enterprise to include in the farm plan as it has the highest shadow price of ¢811,067 Pepper has the

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second highest shadow price, followed by maize/cassava and garden-eggs enterprises (see Table 6.11).

Table 6.10 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Male Farmers

Crop Enterprise	Shadow Price (cedis)
Maize/Cassava	-160119.5
Maize/Plantain	-18009.5
Maize/Cassava/Plantain	-159756.4
Maize/Cassava/Cocoyam	-6491.1
Cassava	-264895
Plantain	-136362.1
Pepper	-1623168.5
Cowpea	0
Tomatoes	-945177.8
Garden-eggs/Pepper	-533212.8

Table 6.11 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Female Farmers

Crop Enterprise	Shadow Price
Maize/Cassava	-652650
Maize/Plantain	-255928.5
Maize/Cassava/Plantain	-270000
Cassava	-811066.7
Plantain	-394307.3
Pepper	-765836.7
Cowpea	0
Garden-eggs	-614000
Garden-eggs/Pepper	-409666.7

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6.3.4 Sources of Food for Consumption

To ensure food security at the household level, a consumption constraint was included in the model (refer to mathematical formulation in section 5.3 in Chapter Five). The consumption constraints were to guarantee that the farmer had sufficient food to meet the food needs of all members of the household. From the literature review, it was seen that food security does not mean that the farmer produces all that the household consumes but includes the ability to purchase food for consumption. Food purchasing activities were included whereby farmers have the option of purchasing or producing the staple crops they eat. The consumption requirement is based on the average size of the household. The average size of the household is similar for all the four farmer groups in the base scenarios, hence they all have the same level of consumption requirement.

Table 6.12 and 6.13 present the amount of each produce that the farmers consume from production and what they consume from purchased produce respectively. The last column in the table shows how much it will cost the farmer for choosing to buy one unit of the produce in question. When given the option of producing or purchasing food for home consumption, the results show that farmers prefer to consume from their own production. It is quite costly to buy maize for consumption, especially stored maize. The model does not force farmers to produce what they consume.

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Table 6.12 Sources of Food and Consumption Patterns for Male Farmers

Produce	Requirement	Source of Produce		Cost to Farmer for Purchasing (cedis)
		From own Production	Purchased	
Maize - Major	4 Mini-bags	All	0	70736
- Minor	3.5 Mini-bags	All	0	87056
- Major Stored	2 Mini-bags	All	0	101193
- Minor Stored	3 Mini-bags	All	0	117512
Cassava	10 Mini-bags	All	0	51096
Plantain	140 bunches	All	0	6160

Table 6.13 Sources of Food and Consumption Patterns for Female Farmers

Produce	Requirement	Source of Produce		Cost to Farmer for Purchasing (cedis)
		From own Production	Purchased	
Maize - Major	4 Mini-bags	All	0	81667
- Minor	3.5 Mini-bags	All	0	100000
- Major Stored	2 Mini-bags	All	0	115000
- Minor Stored	3 Mini-bags	All	0	133333
Cassava	10 Mini-bags	All	0	58000
Plantain	140 bunches	All	0	5525

6.4 Results Based on Whether or Not Farmer Participated In Agricultural Projects

This section presents the results of the optimization analysis for the farmers who participated in agricultural programmes and those who did not. The optimal farm plan for farmers who received agricultural assistance or participated in agricultural programmes consists of maize in the major and minor seasons, maize/cassava, maize/plantain, cowpea and garden-egg enterprises (Table 6.14). About three acres of minor season maize were produced and the 3 acres allocated for the production of vegetables were exhausted in

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garden-egg production.

The crop enterprises selected for farmers who did not receive agricultural assistance are presented in Table 6.15. The area allocated for the production of vegetables was exhausted with the garden-egg/tomatoes enterprise. Again, vegetables have proven to be profitable but some tomatoes is produced this time. The value of the objective function is higher for participating farmers than non-participating farmers.

Table 6.14 Optimal Farm Plan for Agricultural Assistance Recipients

Solution	Crop Enterprises in Solution	Level (Acres)
Optimal Income 7,124,265.3 cedis	Major Season Maize	1.5
	Minor Season Maize	3.1
	Maize/Cassava	0.6
	Maize/Plantain (M/Pt)	1
	Cowpea	0.6
	Garden-eggs (GE)	3

Table 6.15 Optimal Farm Plan for Farmers Without Any Assistance

Solution	Crop Enterprises in Solution	Level (Acres)
Optimal Income 5,307,441.9 cedis	Major Season Maize	0.7
	Minor Season Maize	2.7
	Maize/Plantain (M/Pt)	0.6
	Maize/Cassava/Plantain/Cocoyam (M/Cs/Pt/Cy)	1.1
	Garden-eggs/Tomatoes	2

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6.4.1 Resource Use for Farmers With and Without Agricultural Assistance

Land

The amount of land available for farming for farmer with and without agricultural assistance is presented in Table 6.16. Operator land is constraining for farmers who received agricultural assistance and the optimal income will be increased by 80,000 cedis if one acre of land is made available to these farmers.

Both operator land and rented land were constraining for farmers who did not receive agricultural assistance. The shadow prices for own land is higher for those who did not receive agricultural assistance than those who received. At the margin, land additional land may be more productive for non-participating farmers.

Capital

The capital allocated for use in the major and minor seasons were all used up. In addition, the total amount made available for borrowing was used up. More of the borrowed capital was used in the major season than in the minor season (Table 6.17). The total amount of 400,000 cedis and 500,000 cedis borrowed by participating and non-participating farmers , respectively, was repaid.

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Table 6.16 Land Use for Farmers With and Without Assistance

Activity Type		Amount Available	Amount Used	Slack	Shadow Price
Farmer With Agricultural Assistance					
Land: major season	- Own	5	5	0	80000
	- Rented	3	2.7	0.3	0
Land: minor season	- Own	5	5	0	80000
	- Rented	3	2	1	0
Farmer With No Agricultural Assistance					
Land: major season	- Own	4	4	0	110282
	- Rented	2	2	0	71167
Land: minor season	- Own	4	4	0	110837
	- Rented	2	2	0	71723

Table 6.17 Capital Availability and Use for Farmers Without Agricultural Assistance

Activity Type		Amount Available (¢)	Amount Used (¢)
Farmers With Agricultural Assistance			
Capital: Own:	- Major season	340000	340000
	- Minor Season	160000	160000
Borrowed:	- Used in Major	400000	330633
	- Used In Minor		69367
Capital Repayment		Total Amount Borrowed	400000
Farmers With No Assistance			
Capital: Own:	- Major season	360000	360000
	- Minor Season	190000	190000
Borrowed:	- Used in Major	500000	488925
	- Used In Minor		11075
Capital Repayment		Total Amount Borrowed	500000

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Labour

The availability and use of labour for farmer groups who received agricultural assistance and those who did not are presented in Tables 6.18 and 6.19 respectively. For farmers who received agricultural assistance, family labour was fully used up in the periods of March/April, July/August, and September/October. The increase in the optimal income for making one labour-day available in these month periods of scarcity of labour are shown in Table 6.18. Making more labour available for hiring will not add anything to the revenue position of participating farmers because they hired no labour. Labour is more constraining for farmers who did not receive agricultural assistance (Table 6.19).

Table 6.18 Labour Use For Farmers With Agricultural Assistance

Month	Available		Use		Slack		Shadow Price	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Jan/Feb	112	37	23	0	89	37	0	0
Mar/Apr	112	37	112	0	0	37	1880	0
May/June	112	37	100	0	12	37	0	0
July/Aug	112	37	112	0	0	37	10759	0
Sept/Oct	112	37	112	0	0	37	2683	0
Nov/Dec	112	37	52	0	60	37	0	0

Table 6.19 Labour Use for Farmers Without Assistance

Month	Available		Use		Slack		Shadow Price	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Jan/Feb	112	34	25	0	63	29	0	0
Mar/Apr	112	34	88	2	0	27	5867	0
May/June	112	34	88	29	0	0	7618	1751
July/Aug	112	34	88	1	0	28	5867	0
Sept/Oct	112	34	88	14	0	15	5867	0
Nov/Dec	112	34	32	0	56	29	0	0

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6.4.2 *Revenue Generated From Different Crops*

The revenue generated by each crop, estimated based on whether or not the farmer received agricultural assistance, was calculated to see the relative profitability of the various crops in the optimal farm plan. This is the total revenue from each of the crops in the enterprises that entered the farm plan, and therefore represents what would be the situation when the farmer follows the proposed farm plan. The results are shown in Tables 6.20 and 6.21 respectively. The vegetables have again proven to have the highest revenue with garden-eggs leading with the highest revenue of 5.7 million cedis for those who received agricultural assistance and cultivated a total of 3 acres. The revenue from garden-eggs was 2.5 million cedis for those who did not receive agricultural assistance and who cultivated a total of 2 acres. Maize stands second to vegetables in the amount of revenue generated to the farmer.

A greater level of diversification was found with farmers without assistance. These farmers produced all the crops that appeared in the enterprises of the optimal farm plan beyond what was needed for home consumption. Accordingly, they sold some proportion of each crop. Farmers with agricultural assistance neither sold any cassava nor plantain (Table 6.20).

The results of the LP model that compared the production level of participants and non-participants in the Food-for-Work project in Kenya showed that the net income of participants was higher than non-participants (Benuneh, Deaton and Norton, 1991). In this research, participating farmers had higher total revenue (¢8,183,100) than non-participating farmers (¢6,561,600). Those with agricultural assistance had higher levels of most resources than those without, and as a result, the revenue levels of those with agricultural assistance were also higher. Any payments made by the farmer towards aspects of the assistance received are included in the calculations.

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Table 6.20 Revenue From Various Crops for Farmers With Agricultural Assistance

Crop	Measurement	Amount Produced	Quantity Sold	Price Per Unit	Revenue per Crop (¢)
Maize - Major	Mini-bags	39.0	33.1	35000	1158500
Maize - Minor	Mini-bags	31.3	8.2	38000	311600
Stored maize			16.6	50000	830000
Cassava	Mini-bags	10.0	0	22000	0
Plantain	Bunches	140.0	0	4500	0
Cowpea	Mini-bags	3.8	3.8	60000	228000
Garden-eggs	Mini-bags	435.0	435	13000	5655000
Total Revenue from all Crops					8183100

Table 6.21 Revenue From Various Crops for Farmers With No Assistance

Crop	Measurement	Amount Produced	Quantity Sold	Price Per Unit	Revenue per Crop (¢)
Maize - Major	Mini-bags	24.3	18.3	45000	823500
Maize - Minor	Mini-bags	22.6	16.1	50000	805000
Cassava	Mini-bags	17.9	7.9	22000	173800
Plantain	Bunches	295.4	155.4	4500	699300
Cocoyam	Mini-bags	13.2	13.2	15000	198000
Garden-eggs	Mini-bags	190.0	190	13000	2470000
Tomatoes	Mini-bags	58	58	24000	1392000
Total Revenue from all Crops					6561600

The enterprises which did not enter the optimal solution are presented in Table 6.22 for farmers with agricultural assistance. Their shadow prices are presented to show the cost of forcing one acre of the enterprise into the farm plan. Any of these enterprises can be forced into the production plan by the inclusion of a constraint. However, it will cost farmers with assistance over one million cedis to force pepper into the farm plan. Though tomatoes did not enter the farm plan, there is no cost associated with including an acre of tomatoes into the model.

Table 6.23 portrays the cost of forcing to produce one acre of the enterprises that did not enter the farm plan for farmers without agricultural assistance. Again, it costs more

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than one million cedis to force the pepper enterprise into the farm plan, and about ¢466,000 for tomatoes. Cowpea is the least expensive to incorporate in the optimal plan.

Table 6.22 Shadow Prices of Crop Enterprises Which Did Not Enter the Solution for Farmers with Agricultural Assistance

Crop Enterprise	Shadow Price (cedis)
1 acre of Cassava	47686.9
1 are of Plantain	12212.7
1 acre of Pepper	1125377.5
1 acre of Tomatoes	0

Table 6.23 Shadow Prices of Crop Enterprises Which Did Not Enter The Solution for Farmers Without Agricultural Assistance

Crop Enterprise	Shadow Price (cedis)
1 acre of Maize/Cassava	318052.9
1 acre of Maize/Cassava/Plantain	149410.4
1 acre of Cassava	346552.4
1 acre of Plantain	144806.3
1 acre of Pepper	1035051.8
1 acre of Cowpea	59666.9
1 acre of Tomatoes	466202.6
1 acre of Garden-Eggs	213405.8

6.4.3 Sources of Food For Consumption

As mentioned earlier, consumption constraints were included in the model to ensure that farmers have sufficient food to meet the food needs of all the members of their household. These requirements are based on the size of the household. The model allows

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the farmer to either consume from own production or purchase the produce for home consumption; he is not forced to consume from own production. Purchasing activities were included to allow the farmer purchase food needs for the home if producing other crops is more profitable. The results are shown in Table 6.24 for those who received agricultural assistance, and Table 6.25 for those who did not receive any agricultural assistance.

As in the case of male and female farmers, it is more preferable for these farmers to consume what they produce than purchase the produce for consumption. The shadow prices are very high for those who received agricultural assistance, and is as high as 170,000 cedis for stored maize of the minor season. It is therefore advisable for these farmers to produce what they consume than purchase the produce for consumption. The cost to the farmer for purchasing the produce for consumption is much lower for those who did not receive agricultural assistance. Some of the farmers lamented when the suggestion of purchasing their food needs was put to them as an option. To them, it is highly uneconomical to buy food which they can produce themselves. Though it is good for the farmers (in terms of profit) to concentrate on the production of the products that bring them the maximum income. However, according to the results of the linear programming, which is consistent with the qualitative analysis, the farmers rather prefer producing to at least produce staple food to meet their food needs. This could be due to socio-cultural reasons rather than economic considerations. The price at which they buy the food for consumption was reduced to observe the effect of the decision making process and the model still predicted that farmers consume from own production.

One outstanding issue is the fact that all the food for consumption was taken from own production, and none of the produce was purchased by any of the farmer groups. As discussed in the earlier chapters, due to socio-cultural reasons, farmers in Ghana prefer to produce the food they eat than use their limited income to purchase food.

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Table 6.24 Sources of Food and Consumption Patterns for Farmers with Agricultural Assistance

Produce	Requirement	Source of Produce		Cost to Farmer for Purchasing (cedis)
		From own Production	Purchased	
Maize - Major	4 Mini-bags	All	0	105000
- Minor	3.5 Mini-bags	All	0	130000
- Major Stored	2 Mini-bags	All	0	145000
- Minor Stored	3 Mini-bags	All	0	170000
Cassava	10 Mini-bags	All	0	71489
Plantain	140 bunches	All	0	6055

Table 6.25 Sources of Food and Consumption Patterns for Farmers Without Agricultural Assistance

Produce	Requirement	Source of Produce		Cost to Farmer for Purchasing (cedis)
		From own Production	Purchased	
Maize - Major	4 Mini-bags	All	0	29318
- Minor	3.5 Mini-bags	All	0	38008
- Major Stored	2 Mini-bags	All	0	48875
- Minor Stored	3 Mini-bags	All	0	57565
Cassava	10 Mini-bags	All	0	24938
Plantain	140 bunches	All	0	2345

A summary of all the base scenarios is presented in Table 6.26. From Table 6.26, male farmers have the highest revenue, followed by farmers with agricultural assistance, then those without assistance, with the women farmers offering the lowest.

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Table 6.26 Parameters from All Base Scenarios of the Linear Programming Model

	Male	Female	Agricultural Assistance	No Agricultural Assistance
Optimal income	¢9,388,682.2	¢4,408,807.9	¢7,124,265.3	¢5,307,441.9
Capital Borrowed	Total Allowed	Total Allowed	Total Allowed	Total Allowed
Fertilizer Purchased - Major Season	4.1	3.1	7.1	3.3
Fertilizer Purchased - Minor Season	3.6	2.6	2	2.1
Source of Food Needs	Own Production	Own Production	Own Production	Own Production
Crop with Highest Revenue	Garden-Egg	Garden-Egg	Garden-Egg	Garden-Egg
Crop with Lowest Revenue	Plantain	Plantain	Cassava and Plantain	Cassava
Position of Maize In Generating Revenue	Second	Second	Second	Second

6.5 Sensitivity Analysis

This section discusses sensitivity analysis undertaken with the base model. Parameters of a number of variables were changed and their effect on the farm plan, resource use and decision to produce or purchase food were analysed. These are shocks on the model to make inferences for effective policy formulation. Rented land, hired labour, credit and yield were changed, holding all the other parameters constant in each case. The summary of the changes for simulation is summarized for each farmer group in Table 6.27 below. The details of each simulation and the effect on the base model are also discussed in the next sub-sections.

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Table 6.27 Summary of Scenarios for Simulation

Parameter		Male Farmers	Female Farmers	Agric Assistance	No Agric Assistance
Rented Land	Base	3	2	3	2
	Simulation Level	6	4	6	4
	Percentage Change	100	100	100	100
Hired Labour	Base	37	37	37	29
	Simulation Level	74	74	74	58
	Percentage Change	100	100	100	100
Credit	Base	550000	300000	500000	550000
	Simulation Level	1200000	1200000	1200000	1200000
	Percentage Change	118.2	300	140	118.2
Maize Yield	Base	12.5	11.5	12	10
	Simulation Level	17.5	16.1	16.8	14
	Percentage Change	40	40	40	40

6.5.1 Increase Rented Land

Rented land was 3 acres for male farmers and 2 for female farmers in the base model, reflecting what is representative of the farmers in the study area. Since the LP model is to see what would happen at the optimum, it is necessary to vary the land available for renting and observe the effect on the farm plan (in this case, it is an increase in land). Though some farmers do not have large land holdings, there is the opportunity to double their farms through rented land or share-cropping. The amount of rented land available was increased from 3 acres to 6 for male and from 2 acres to 4 acres for female farmers. This is justified by the fact that in the sample, 43 percent of the farmers had between 2.5 to 5 acres whiles 23 percent had more than 5 acres.

When the amount of rented land was doubled, there was no change in the farm plan nor the income level for male farmers, implying that rented land is not a constraint for them. For the female farmers however, there were major changes in the farm plan and the optimal income level. The main results of this simulation for female farmers are summarized in Table 6.28. The optimal income level increased from about 4.4 million cedis to approximately 5 million cedis. All the rented land was used up in the minor season but there was a slack of about 0.3 acres in the major season. New crop enterprises such as cowpea

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entered the solution.

At the base model, the bulk of the maize produced was stored and sold later. When the amount of rented land available to female farmers was increased, all the surplus maize was sold immediately after harvest and storage was at the level of what was required for home consumption. Another important observation is that all the consumption requirement for the household was produced rather than purchased.

Table 6.28 Effect of Increasing Rented Land for Female Farmers

Parameter	Base Model	Increase in Rented Land
Optimal Income Level	4,408,808 cedis	4,962,783 cedis
Rented Land Available	2 acres - major season 2 acres - minor season	4 acres - major season 4 acres - minor season
Rented Land Use	2 acres - major season 2 acres - minor season	3.7 acres - major season 4 acres - minor season
Crop Enterprises in the Solution	Major Maize 13 acres Minor Maize - 3.3 acres M/Cs/Pt/Cy - 0.9 acres Tomatoes - 2 acres	Major Maize 1.5 acres Minor Maize 1acre M/Cs/Cy - 0.8 acres M/Cs/Pt/Cy - 0.9 acres Cowpea - 2.7 acres Tomatoes - 2 acres
Consumption Requirements	Taken from Own Production	Taken from Own Production

With regards to participation in agricultural programmes, rented land was 3 acres and 2 acres for participating and non-participating farmers, respectively. Rented land for participating farmers was increased to 6 acres and for non-participating farmers, it was increased to 4 acres. This increase had no effect on the linear programming results for participating farmers. However, rented land is a constraint for non-participating farmers and increasing it resulted in a small increase in the optimal income level as well as changes in the basis. The changes are presented in Table 6.29. All the consumption needs were

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taken from own production.

Table 6.29 Effect of Increasing Rented Land for Farmers Without Assistance

Parameter	Base Model	Increase in Rented Land
Optimal Income Level	5,307,442 cedis	5,359,295 cedis
Rented Land Available	2 acres - major season 2 acres - minor season	4 acres - major season 4 acres - minor season
Rented Land Use	2 acres - major season 2 acres - minor season	2.4 acres - major season 2.6 acres - minor season
Crop Enterprises in the Solution	Major Maize - 0.7 acres Minor Maize - 2.7 acres Maize/Pt - 0.6 M/Cs/Pt/Cy - 1.1acres G-Eggs/Tm - 2 acres	Major Maize - 0.1 acres Minor Maize - 2.1acres Maize/Pt - 1.6 acres M/Cs/Pt/Cy - 0.6 acres Cowpea - 0.2 acres G-eggs/Tm - 2 acres
Consumption Requirements	From Own Production	From Own Production

6.5.2 *Increase in Hired Labour*

Though it is difficult to increase family labour, hired labour is available in many rural communities and can be hired if credit is available. As such it becomes necessary to make more hired labour available to the farmers and observe if it leads to any changes in the farm plan as compared to the base model. When money is available, there is the possibility of increasing the amount of hired labour from 30 percent to 60 percent of family labour for all farmer groups. When hired labour was increased, all other variables held at the base, it had no change in the results from the base model for male and female farmers. It can therefore be said that labour is not a constraint if varied in isolation, but land could be needed by these farmer groups.

Increasing the amount of hired labour available had no effect on the model for farmers with agricultural assistance. However, for farmers without agricultural assistance,

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it resulted in minor changes but rather negligible.

6.5.3 *Increase in Credit Availability*

The next sensitivity analysis involved increasing the amount of credit available to the farmers. Within the farming communities, the credit available to these farmers is generally low in comparison to their cost of production. The amount of credit was therefore increased to a level that will allow the farmers to undertake a major and minor maize, maize/cassava and maize/plantain enterprises. From the gross margin calculations, the total cost of undertaking these enterprises is about 1.2 million cedis and the amount of credit was increased accordingly, assuming all other things remained equal, for all the four farmer groups.

The optimal income of male farmers increased from 9.4 million cedis to about 11 million cedis. The credit was almost completely used up and there were changes in the combination of crop enterprises and other activities. With this scenario for male farmers, about 40 bunches of plantain was purchased for home consumption. Farmers who participated in agricultural programmes also recorded an increase in the optimal solution. The optimal solution of female farmers increased by ¢130,000, and for non-participating farmers, it increased by ¢70,000. The effect of an increase in the credit on female farmers and non-participating farmers may be insignificant due to their limited land holdings and it could be said that credit given to farmers benefit them more if other resources are more available.

6.5.4 *Increase in Yield*

For this scenario, it was assumed the government selectively subsidizes fertilizer prices, which is very crucial for the adoption of improved farm technologies. The assumption for this scenario is that the base fertilizer price reduces which leads to an

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increase in the use of fertilizer, which in turn leads to an increase in maize yield, ceteris paribus. This is based on the fact that maize yields are increased by 40 percent (national yield averages in maize is 20 minibags per acre (MOFA, 2000) whiles average yields in the study area was about 12 minibags). The analysis in this scenario resulted in the biggest change in optimal income. Production shocks cannot be wished away because its effects have to be absorbed somewhere within the economic system (Smith, 1997).

Table 6.30 presents a summary of the simulation analysis. The improvement in the optimal solution for female farmers with an increase in yield is most significant, followed by that of male farmers and farmers with agricultural assistance. The detailed results of the simulation are presented in Appendix V.

Table 6.30 Changes in the Income Level with Varying Parameters

		Simulation Parameter			
Farmer Group (*with Percentage Changes and Elasticities*)	**Base Model Income Level**	**Increase Rented Land**	**Increase Hired Labour**	**Increase Credit**	**Yield change**
Male	9388682	9,388,682	9,388,682	10,146,631	10,976,929
% Change In Income		0	0	8.07	16.92
Elasticities		0	0	0.068	0.423
Female	4408808	4,962,783	4408808	4539822	5317057
% Change In Income		12.57	0	2.97	20.6
Elasticities		0.126	0	0.01	0.515
Agric. Assistance	7124265	7124265	7124265	8018777	8147223
% Change		0	0	12.56	14.36
Elasticities		0	0	0.09	0.36
No Assistance	5307442	5359295	5314510	5,377,926	6185319
% Change In Income		0.98	0.13	1.33	16.54
Elasticities		0.01	0.001	0.011	0.414

The elasticities are calculated by dividing the percentage change in optimal income by the percentage change in the simulation parameter

There was a slack in the use of capital for some farmer groups when the amount of

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credit was increased. The simulation results show that female farmers only used about ¢530,000 out of the ¢1,200,000 credit made available to them. They either do not need much credit or the credit was not used due to constraints in land. To test this situation, the land available was increased to the level of male farmers and all the credit was exhausted. Land is therefore a major constraint for female farmers and an increase in their land holding will significantly enhance their income situation. Assistance in the form of small grants will be effective.

It is rather surprising that while increase in credit generated an increase in the objective function value for male farmers and participating farmers, it had very little effect on the income level of female farmers and farmers without agricultural assistance. Increase in credit may not have the desired impact if it is not accompanied by a change in the endowment of other resources. While men need capital, women farmers and farmers without agricultural assistance will not benefit from credit if their land holdings remain the same. Women farmers did not hire labour due to their small land holding and limited credit.

The elasticities in Table 6.30 show that increase in yield is the most effective way of improving farmer's income level. The elasticity for increasing yield on income is 0.5 for female, which is the largest. Furthermore, the elasticity for increasing rented land on income is largest for female farmers and almost zero for the other farmer groups. For yield increases, farmers have the responsibility of adopting improved and good agricultural practices. On the other hand, policy makers may need to consider providing specific subsidies for vital inputs such as fertilizer.

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Chapter Seven

Summary and Conclusion

7.1. Summary

This study examines maize, the main cereal and major staple crop in Ghana, in a farming systems perspective for the Central Region of Ghana. A farming systems approach was employed because hardly does any small-scale farmer in Ghana undertakes the production of individual crop enterprises. It was found necessary to examine the farm unit as a whole in order to determine the profitability of the maize enterprise in relation to other food crops, irrespective of whether or not the enterprise contained maize. In Ghana, maize is a major food crop that determines food security. However, the demand for maize as food and feed grows at the same rate as population growth rate, while maize production trends have not kept pace with population growth. Maize availability for Ghana is necessary to ensure food security.

The study therefore examined the decision-making process of the farmer to improve resource allocation for ensuring household food security. Efficient resource allocation can improve household food availability and income situation of the farmer. In order to examine the availability of maize for household consumption, the relative profitability of the various crops and optimal farm plans were determined for farmers in the study area. Determining the relative profitability disclosed the place of maize in generating income for the farmers among the other food crops.

Since most of the maize produced for direct home consumption is done by women farmers, a gender differential analysis was undertaken to examine whether male enterprises are more profitable than those of their female counterparts. Secondly, the effect of agricultural programmes was assessed by grouping farmers into participating and non-

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participating in agricultural programmes and their various farm enterprises were examined. This is done to show the differences in the performance the enterprises of those to whom agricultural assistance was extended and those who received no assistance.

The objective of the study was to examine the relative profitability of food crop enterprises in the Central Region and determine the optimal enterprise combinations and activities that maximize net farm returns for four farmer groups using a linear programming model. The relative profitability of food crop enterprises was analysed by gender and by participation in agricultural programmes on the basis of the different resource endowments. A policy analysis was carried out using simulation.

A multistage sampling method was used in farmer selection for the survey to obtain data for undertaking a farmer socio-economic analysis. The results of the survey were later used to construct a linear programming model. High maize production districts in the Central Region were determined first using data from the PPMED of the Ministry of Food and Agriculture. Out of the high maize producing areas, three districts were randomly selected namely: Assin, Agona and Mfantsiman districts. From each district, five villages/towns were selected, and out of each village seven farmers were selected. The selection of the farmers was based on farm size and gender. At least 3 farmers in each village were women. A total of 105 farmers were interviewed.

Both qualitative and quantitative methods were used in the analysis in order to achieve the objectives of the study. The quantitative approach involved analysis of food crop enterprises of maize farmers through simulation analysis developed in the framework of mathematical programming. A linear programming model was particularly useful as it provides insight into appropriate decision-making and the results provide a basis for making relevant recommendations to farmers and policy. Besides, a linear programming model is capable of handling intercropping situations effectively. Four representative farmer groups were examined to see the relative profitability and performance of their crop enterprises.

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Resource endowments and use levels were determined and cropping calendars were constructed for the farmer groups to determine the labour-days involved in each enterprise. Other data considerations were made to obtain information for crop enterprise budgets where gross margins were calculated. In addition to cropping activities, the linear programming model included input use, selling, storage activities, as well as activities for purchasing major staples for household consumption. The LP matrices incorporated the variable costs and returns from the different enterprises. The Central Region has two cropping seasons and this was used in the construction of the LP model. The base models were first run and the simulation analysis was based on the base scenarios. Sensitivity analysis was used to determine the stability of the optimal solution by varying the values of the limiting resources such as rented land and credit. Changes in rented land resulted in about 13 percent change in the optimal income level for female farmers.

7.2 Limitations of the Study

The research covered all the possible areas that it set out to investigate. However, the model studied only food crop enterprises and did not include perennial and other tree crops in the LP model due to the limitation of sufficient and detailed data. The model also covered only a part of the country and may not be able to provide generalised recommendations for the whole country. Thus, this study will need to be extended to other parts of the country in order to make more general recommendations for national food security. The model, analysis and results form a strong basis for a further long-term research on the topic and provides insights useful for policy formulation.

7.3 Major Findings and Conclusions

The maize-based farming systems in the Central Region are characterized by maize cropped as an individual crop or in combination with cassava, plantain, cocoyam and

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sometimes with vegetables. Other crops in the region include yam, garden-eggs, pepper, tomatoes and cowpea. Of these, all except yam were used in the analysis. Tree crops are also grown such as cocoa, coffee, citrus, and oil palm. Mixed cropping is often practised in the region. The region has two cropping seasons in a year namely, major and minor seasons.

Maize is the most important cereal crop to the farmers and is grown both for sale and for home consumption. The crop is termed 'good mother' by some women farmers because it makes it possible to feed the family. Availability of maize gives them a sense of food security and many farmers wondered how they could take care of the family without maize. Maize also provides quick and regular income to the farmer, in addition to its ability to store for a long period of time unlike the vegetables. The main problems identified by farmers as being constraints in food production were lack of sufficient money for farming, labour related issues, marketing of produce and land problems.

No crops were found to be specific only to women as asserted by some researchers. Crops grown were common to both male and female farmers. Crop enterprise combinations differed between farmers with and without agricultural assistance. Farmers with assistance had fewer crop combinations in their enterprises. Female farmers were more resource constrained than their male counterparts as they had smaller farm sizes, used less credit and yet faced the same input and output prices with male farmers. Out of the 46 women who were interviewed, only 5 had food crop farms of more than 5 acres while 18 men were in this category.

Few female farmers benefited from agricultural assistance from MOFA and NGOs in the region. Out of the respondents, only 8 women were part of these programmes. All the 8 women applied fertilizer on their farms and their farm enterprises performed better than the women who did not participate in the programmes. This shows that women have the ability to increase agricultural production if they have the incentive to do so.

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The results of the linear programming analysis showed that farm enterprises of male farmers performed better than those of female farmers. This is consistent with the gross margin analysis. Furthermore, participating farmers in agricultural programmes had a relatively more productive enterprises than non-participating farmers, which may be due to their better position in terms of resource endowment.

The LP results also showed that land is the most limiting factor of production for female farmers and their optimal income will increase with an improved access to land. The shadow prices for land were higher for female farmers than male farmer, which could mean that the productivity of land may be higher for female farmers compared to male farmers.

From the results of the base LP scenarios, maize was the second revenue generating crop in relation to other crops. In most cases, garden-eggs was the highest revenue generating crop. With maize being relatively profitable, coupled with the fact that farmers prefer to grow their own food for home consumption, it can be concluded that devoting more resources to maize production will not result in an economic loss to farmers.

Maize is a vital staple crop and most important cereal crop because of its diverse uses in food preparation, and its ability to be stored for several months and either sold or consumed throughout the year. On the other hand, vegetables are perishable; they cannot be stored. Vegetables are also not consumed in large quantities and are produced mainly for the market. Maize can therefore be said to be the most profitable staple food crop and demands attention for an improvement in its enterprises.

From the LP model, when given the option of producing for household consumption and purchasing staples for home consumption, all consumption was taken from production for all farmer groups. None of the staple food crops indicated in the model was purchased for consumption in the base scenarios. The results showed that the opportunity cost of purchasing staple food crops such as maize, cassava and plantain for consumption was very high. This is consistent with the survey results where farmers indicated a preference

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against purchasing staples food crops for home consumption. This is the usual behaviour of most subsistence farmers in the African subregion. Small-scale farmers in Ghana have needs that compete for their limited income.

A sensitivity analysis of the linear programming model, which involved an increase in yield due to a reduction in the price of fertilizer led to a considerable increase in income level. The income elasticity with respect to increase in yield was largest for all farmer groups, but especially for female farmers. From the survey results, farmers have indicated that they will increase the use or try the use of fertilizer with a decrease in its price and vice versa. Farmers are not able to purchase enough quantities of fertilizer and a decrease in price will make a difference in use, yield and their income level.

Farms in Ghana need to be well managed and operated in order to obtain maximum and continuous flow of incomes that are comparable with earnings outside agriculture. Micro level analysis of farm profitability is needed for different parts of the country as macro analysis may not capture the essential issues at the farm household level. When farmers are sure to obtain maximum and continuous income from maize, they will increase the acreage allocated to the crop, else, they will only grow enough for household consumption and grow more profitable crops for sale. Farm enterprises can be improved without a heavy dependence on foreign assistance and new and expensive technology, if it is better managed to obtain a marketable surplus.

Finally, as a nation, we need to take a closer look at the role of rural farmers, who form the majority of the national labour force, in order to achieve the goals of national economic development. To achieve the objective of national economic growth, the agricultural sector can neither be neglected nor overlooked.

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7.4 Policy Implications of Findings and Recommendations

The following recommendations are made from the study.

Efforts must be made to ensure an improvement in the production base and income level of women farmers. Women farmers were found to devote a greater proportion of their farm produce to home consumption than men, leaving them with little surplus for sale. The sensitivity analysis shows that the effect of increased yield is largest for female farmers. Yields can be increased with increased use of inputs and improved farm management methods. This can be facilitated by policy to introduce selective subsidies on fertilizers for small-scale women farmers as this will go a long way to improve their farm productivity and income levels significantly. An increase in their income level is vital as having maize alone is not sufficient for food and nutrition security. They need fish, meat, and other ingredients for proper food preparation which they ought to purchase outside of their production. NGOs working in the communities and promoting agricultural production should pay attention to women farmers by assisting them with small grants, improved seed and inputs. The government would need to take a closer look at ways of making inputs affordable for small-scale food producers.

Extension service delivery needs to be intensified by MOFA staff as well as NGOs. Since the highest improvement in income level for all farmer groups was seen with an increase in yield, the adoption of improved agricultural practices is critical for farmers in the study area. One way to increase yield is through assistance to obtain agro-chemicals at a reduced price but the other way is with improved farm management practices. Extension workers in the region should be trained in farm management practices to enable them extend the findings of practical and farmer-oriented research to farmers. Extension officers also need more information on the crops grown in their area of operation in the form of handouts and reading materials for improved extension delivery.

Research findings on maize in the study area should be made available to a wider

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group of farmers, especially women farmers. Farmers talk about improved varieties but have little practical knowledge about them. The number of female extension workers would need to be increased as most women farmers find it easier relating to female field workers than male workers. The women farmers interviewed were particularly happy to communicate a lot of information to me, a female researcher, as they could easily identify with a woman.

An increased access to credit for all farmer groups in the study area is critical. Farmers generally received very little credit, purchased little farm inputs and had poor yields. Most farmers never received any credit for farming. The sensitivity analysis of the linear programming model also shows a positive increase in income with an increase in credit. Credit institutions in the rural communities should be sensitized, equipped, empowered and encouraged to give credit to farmers. Adequate and timely credit availability will enable farmers purchase improved farm inputs in a timely way, rent land and hire labour for improved performance of their farm enterprises.

Bottlenecks such as the collateral requirements in forms not readily available to farmers, especially women need to be removed. Credit institutions often demand collateral security from farmers in forms they do not have. Land title, for example, should not be used as collateral for obtaining credit for women farmers. The farm itself could be used as a basis for granting loans to small-scale farmers. Lack of sufficient credit is a limiting factor in production activities as it determines the availability and use of appropriate inputs on the farm. The amount of loan the farmers can borrow is too small to enable them undertake their major farm activities. Nevertheless, the sensitivity analysis of the LP programme further suggests that making more capital available to female farmers without an increase in the amount of land for farming will not benefit them. Both land and credit constrains must be addressed.

Land reforms are needed at community level in order to make land more accessible

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to women farmers, especially. Land is found to be a major constraint to female farmers than male farmers with higher shadow prices and it also generated an increase in the objective function value in the sensitivity analysis. Improving credit to farmers cannot benefit them fully if their access to land is not changed. Making land available to female farmers is the responsibility of the local communities. Though land is the most constraining resource to the female farmer, their land might be more productive than that of the male farmer due to the higher shadow prices. Men and women do not have equal social, economic and legal rights in the Ghanaian traditional culture. Land rights of women is usually user rights rather than ownership land title rights.

Greater and more secure access to land is required for rural women beyond customary systems, which regulate access according to membership of a lineage, community or household. This is even more important due to increasing population and as land is no more in abundance. Measures to increase women's control over land are important strategies to empower rural women to make food production decisions more effectively and enhance their chances of obtaining credit. Government efforts should be geared towards improving the rights of women to agricultural productive resources such as land and credit due to their vital role in ensuring food security.

Participation in agricultural programmes is a strong incentive for farmers to embark on modern techniques of farming, thereby leading to increased yields and efficient use of resources. Agricultural projects therefore have a great influence on productivity. However, out of the total number of women interviewed, only 17 percent participated in these agricultural projects. There seems to be a bias in the distribution of such assistance against women farmers. It was interesting to find that all the women farmers who participated in the programmes applied fertilizer on their farms. Efforts must be made to include more women in agricultural programmes to ensure an improved performance of their enterprises. Government organizations and NGOs that extend agricultural programmes to farmers must

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educate male farmers to contribute more to household food security. Diverse types of information and education are needed by farmers in order to improve their livelihood, consumption patterns and welfare in general.

The survey showed that the educational level of the female farmers is particularly low and is therefore a matter of concern. Formal and informal education opportunities for rural women is an issue that demands attention of national governments, the international bodies and non-governmental organisations. The education level of rural women in Africa has been a basis for discrimination against them in the distribution of credit and other forms of agricultural assistance. Low levels of education has also contributed to the ignorance of their rights and provisions of the law. Education enables the farmer to attempt modern methods of farming more easily. Adult literacy programmes must be extended to farming communities in the Central Region of Ghana. Simple literacy and numeracy programmes will place the farmers in a position to understand and attempt improved farm management practices.

Farmers must be encouraged to undertake simple household record-keeping and recording exercises on all the enterprises and non-farm activities. The presence of good records from the farm enable researchers to carry out more rigorous analysis leading to recommendations for policy formulation towards enhancing farm productivity and improving farmer welfare. Good farm records will enable farmers to make informed farm decisions, present their needs to government in a practical way, and these records will supplement the data collected by the Ministry of Food and Agriculture and other bodies.

Good irrigation and drainage systems are needed to prevent complete crop failure when there is not enough rain and when there is too much rain. The farmers in the garden-egg growing areas in the Mfantsiman District have located their farms close to each other to enable them use tractors in ploughing the land. This will be a good place to start an irrigation project. These farmers are industrious and will be able to increase the production

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base of both maize and vegetables.

7.5. Recommendations For Further Study

This study forms a strong basis for further research. Food insecurity must be fought as an inter-sectoral issue. In a follow-up study, cross-sector studies would be relevant to see the degree of impact the agricultural sector has on other major sectors of the economy. Arnade (1996) found that both the manufacturing and services sectors of the US economy had significant influence on aggregate agricultural output, whereas agriculture has less impact on manufacturing and on service output. Sectoral models address the need for an overall policy plan which considers all related sectors, industries, products, and other related factors simultaneously (Zyl, 1989b; Arnade, 1996). Such a policy design is vital for the economy of Ghana.

A study that analyses and demonstrates the importance of ensuring a maximum, continuous and sustained income level for maize farmers and the role of maize in food security in Ghana is necessary for many parts of the country.

At the farm level, research should maintain a farming systems approach as farmers in Ghana hardly grow crops cultivated individually, especially in the food crop enterprises. The results of such research would give a total view of the farm sector and provide the farmers with a practical decision making tool. Further research could also incorporate perennial crops in the analysis.

Soil scientists and agronomist could be involved to test the soils in the different areas and analyze the differences in soil type, level of fertilizer use and yields. LP matrices can then be built to see the optimal farm plans for the different soil types.

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Appendix I: Interview Schedule

Interview Schedule for Maize Farmers

Research Topic: An Optimization Analysis of Maize-Based Farming Systems in the Central Region of Ghana

Farmer Number _____ Name of Interviewer _____

Farmer's Name: _____ Sex [ ] M; [ ] F

District of Interview: _____ Town/Village: _____

Date: _____ /199___ Time Interview Started: _____ a.m./p.m.

I. *Crop Information*

1. What is your major occupation? _____

1a. What is your minor occupation? _____

2 For how many years have you been farming? _____

3. Please rank the crops you grow in order of importance (starting with the most important).

Crops Grown	No. of Years Grown	Reason for growing crop
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8		

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4. What crop combinations do you usually grow? Please tell us why (*Continue writing overleaf).*

   a. _____

   b. _____

   c. _____

   4a. Do you sometimes plant beans/cowpea with the aim of enriching the land? [ ] Yes;[ ] No

5. If you always grow some maize, please tell us why. _____

   _____

   _____

6. Please complete the table below on the area of each crop or crop mixtures you cultivated.

Crop/Crop Mixtures	Area cultivated		
	Major '97	Minor '97	Major '96
1.			
2.			
3.			
4			
5			
6.			
7.			

7. How much maize do you intend to plant next season?

   [ ] Same size as last season;

   [ ] Less than last season;

   [ ] More than last season.

   7a. Specify acreage _____ acres

8. What would make you allocate more resources to expand your maize production?

   _____

   _____

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9. How many times do you usually plant maize on the same plot before changing to another crop?

_____

10. Describe the problems you face as a farmer.

_____

_____

_____

II. *Cost*

11. Please list the assets (including cutlasses and other equipments) on your farm and their value.

_____

_____

_____

12. What equipments did you have to buy last year and what was the cost (including crib construction cost)? _____

_____

_____

13. Do you use tractors? [ ] Yes; [ ] No.

13a. If yes, how much did you spend last major season for preparing your farm? _____ cedis

14. How much did you spend on seed last major season?

Crop	Quantity of Seed Bought	Price Per Unit (¢)	Source of Seed	Total Area Planted
1. Maize				
2.				
3.				

15. Do you apply fertilizer on your farm? [ ] Yes; [ ] No. If no, go to question # 17.

15a. What type(s) of fertilizer do you apply? _____

15b. How much did you spend on purchase and application last major season?

(i) Quantity bought of each type _____

(ii) Unit price of each type _____ cedis

(iii) Cost of application _____ cedis

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16. In which year did you start using chemical fertilizer? _____

16a. From which source(s) do you obtain your chemical fertilizer? _____

17. Have you ever used chemical fertilizer in the past and then stopped using it? [ ] Yes [ ] No.

17a. If yes, when did you stop using it? _____

17b. What is your reason(s) for discontinuing the use of chemical fertilizers? _____

_____

18. What would be your response to the following changes in the price of fertilizer?

Increase: _____

Decrease: _____

19. Do you use herbicide (or weedicide) to control weed on your farm? [ ] Yes; [ ] No.

19a. If yes, please indicate the following:

[ ] Quantity purchased _____

[ ] Cost of chemical _____ cedis

[ ] Crops on which applied _____

20. Tell us about the manual weeding of the plots (by crops) last season (major, 1997).

Crops\ Crop Mixtures	No. of times weeded Before Harvest	Crops\ Crop Mixtures	No. of times weeded Before Harvest

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21. How much did you spend on labour last season (major '97) for the following activities?

Plot/Crop	Activity	No. of People	No. of Days Worked	Amount Paid (total)
	Clearing			
	Weeding			
	Harvesting*			
	Other			
	Clearing			
	Weeding			
	Harvesting*			
	Other			
	Clearing			
	Weeding			
	Harvesting*			
	Other			

** Harvesting cost includes hired labour cost, feeding and others.

22. Do you have access to irrigation or drainage facilities? [ ] Yes; [ ] No

23. Do you treat your maize with a chemical before storage? [ ] Yes; [ ] No

23a. If yes, please complete the table below.

Chemical Used (Indicate Storage Method Used)	Quantity Used (Last Major Season)	Amount Spent Cedis

24. How much transportation and other costs did you incur in selling your produce?

Crop/Produce	Transportation Cost (¢)	Other Selling Costs (¢)
1. Maize		
2.		
3.		

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25. Have you ever received any loan for your farming activities? [ ] Yes; [ ] No

25a. If yes, what is the source? _____

25b. How much did you receive last year? _____ cedis

25c. What was the rate of interest? _____%

26. Please tell us of any difficulties you encountered in obtaining a loan.

[ ] Never applied for loan [ ] Process very complicated

[ ] Bank is too far away

[ ] Applied but did not receive (reason) _____

[ ] Other reasons are _____

_____

27. Do you receive assistance from any Agricultural Institution (including NGOs)? [ ] Yes; [ ] No.

27a. If yes, what form of help did you receive?

[ ] Cash [ ] Seed [ ] Fertilizer

[ ] Marketing [ ] Insecticide [ ] Technical Assistance/advice

[ ] Other (specify) _____

27b. What are the terms of the assistance? _____

_____

II.1 *Labour (Cost)*

28. Including yourself, how many people live in your household (ie. eat from the same 'pot')? ____

29. How many people in your household are available for labour on your farm?

[ ] Men _____ [ ] Women _____

[ ] Children _____ [ ] Other _____

30. How many days a week on average do they work on the farm? _____ days

(*Note festival, resting and worship days when counting*)

30a. How many hours is usually spent per day on the farm by:

[ ] Yourself _____hrs [ ] Other household members _____ hrs

[ ] Hire labour _____ hrs

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31. How many people do you have as hired labour?

[ ] Full-time _____

[ ] Part-time _____

32. How many workers do you need on your farms (excluding yourself) on a:

	Family Labour	**Hired Labour**
Full-time basis	_____	_____
Part-time basis	_____	_____

33. How many days does it take to clear and weed one acre by:

	Clear (days)	**Weed (with crops on farm)**
Family Labour	_____	_____
Hired Labour	_____	_____

34. Please allocate the labour available to you according to the labour demand level of each crops/crop combinations. Thus, the labour requirement level of each crop enterprise.

Crop/Crop Combination	***Labour Requirement (%)****
_____	_____
_____	_____
_____	_____
_____	_____
Total	_____

** The percentages should add up to 100%*

35. Please describe the problems you have in mobilizing labour? _____

_____

36. How much money did you have available for farming activities last year? _____cedis

37. Approximately, what proportion of your income is invested in the following areas of your farm?

Crop	***Percentage***	***Crop***	***Percentage***
[ ] Maize	_____	[ ] Cassava	_____
[ ] Other Food Crops	_____	[ ] Tree Crops	_____
[ ] Other Cash crops	_____	[ ] Vegetables	_____
[ ] Livestock	_____		

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III *Income*

38. Please tell us about the harvest of the crops you grew last major season.

Crop	Area Cultivated	Qty Harvested (Total)	Qty Sold	Qty Consumed
1. Maize				
2.				
3.				
4.				
5.				
6.				
7.				

39. Complete the table below to give us your sales information for all the crops you grow.

Crop	Unit of Measurement	Qty Sold	Sale Price Per Unit	Remarks
1.				
2.				
3.				
4.				
5.				
6.				
7.				

40. How much produce do you have in storage? _____

41. When do you usually sell your maize?

[ ] Fresh green harvest

[ ] Immediately after harvest (dry)

[ ] If you store the maize, please tell us for how long:

Major season maize: stored till _____

Minor season maize: stored till _____

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42. What problems do you have with storage and storage facilities? _____

_____

_____

43. How do you sell your maize?

[ ] Sold directly to market [ ] Sold to middle man

[ ] Sold to cooperative (of which I am a member)

[ ] Others (specify) _____

44. What problems do you encounter in marketing/selling your maize? _____

_____

45. Please tell us how much maize you need for home consumption:

[ ] Every week _____ [ ] Each season _____

[ ] Each year _____

46. Do you sometimes have to buy some farm produce when your stock is finished? [ ] Yes; [ ] No.

47. Tell us about your purchases of additional farm produce for home consumption when your stock is finished. These are the crops that you produce and still have to buy sometimes.

	Crop/Produce	Frequency of Purchase	Quantity Purchased	Price Paid/ Unit
Last Year	1. Maize			
	2. Processed Maize			
	3.			
	4.			
	5.			

48. Please complete table below if you keep livestock.

Type of Livestock	Quantity Kept	Amount Spent On Each Last Year

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48a. How many of each type did you sell last year and at what price (including egg sales)?

Type of Livestock	Quantity Sold	Price Per Unit
Eggs	crates/day	/crate

49. Do you have any income from outside the farming activities? [ ] Yes; [ ] No.

50. Please tell us the source, if you have off-farm income (thus, pension, teaching, trading, remittances from children, etc.)?

Income Source(s)	Amount Obtained (¢)	How Often Received
1.		
2.		
Plans For The Future		

51. Which planting method(s) do you use to cultivate your maize?

Local Maize: [ ] Row Planting [ ] Random planting

Improved Maize: [ ] Row Planting [ ] Random planting

52. Do you currently have any contacts with Agricultural Extension staff? [ ] Yes; [ ] No

52a. If yes, how does the contact take place?

[ ] Individual visits [ ] Group visit with other farmers

[ ] Other (specify) _____

52b. How often are these visits? _____

52c. How have you benefited from the extension staff? _____

_____

53. Where do you get information about farming? Please check all that apply.

[ ] Agricultural Extension [ ] Radio [ ] Demonstrations Farms

[ ] Other farmers [ ] TV [ ] Farmer's Day

[ ] Farmer Meetings [ ] Other (specify) _____

53a. Which two of these sources are most important to you?

_____

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IV *Demographic Information*

54. Please tell us your age: _____ years old

55. How many children do you have? _____

56. What is your marital status?

[ ] Married [ ] Single

[ ] Divorced [ ] Widowed

56a. If married, what role does your marriage partner play towards your farming?

[ ] Assists in clearing land [ ] Assists in weeding among crops

[ ] Assists in harvesting [ ] Other (specify) _____

57. What is your religious affiliation?

[ ] Christian [ ] Moslem

[ ] Other (specify) _____

58. What level of education do you have?

[ ] Never had formal education

[ ] Primary school level

[ ] Secondary ('O' Level/' A' Level)

[ ] College (Specify College and course taken) _____

[ ] University Degree and above:

(Specify Institution and course taken) _____

[ ] Other (specify) _____

59. What do you plan to be doing 5 years from now? _____

60. How many farms do you have? _____

Farm	Size (Acres)	Crops on Farm

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61. What is the total land available to you? _____

61a. What type of land ownership do you have?

[ ] Rent _____ acres/ha [ ] Family Land _____ acres /ha

[ ] Purchased Land _____ acres /ha [ ] Share Cropping _____ acres/ha

62. What is the arrangement between you and the landowner for the use of the rented land? _____

_____

63. Please feel free to tell us any other comments that you have.

_____

_____

_____

_____

Time Completed: _____ a.m./p.m.

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Appendix II

Cropping Calendars On Per Acre Basis

Maize - Major Season

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Hoe	4
Tree Felling	March	Cutlass & Axe	6
Planting	April	Rope, Cutls, Hoe	7
Fert Appl	April	Cutlass	6
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvesting	July- Aug	Baskets/Bowls	12
Total Labour Requirement			**46**

Maize - Minor Season

Activities	Month	Tools Used	Labour Days
Clearing	August	Cutls, Hoe	4
Tree Felling	August	Cutlass & Axe	4
Planting	September	Rope, Cutls, Hoe	7
Fert Appl	October	Cutlass	6
1st Weeding	September	Hoe	7
2nd Weeding	October	Hoe/Cutlass	4
Harvesting	Nov-Dec	Baskets/Bowls	12
Total Labour Requirement			**44**

Maize/ Cassava

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	8
Tree Felling	March	Cutlass & Axe	6
Plant Maize	April	Rope, Cutls, Hoe	7
Plant Cassava	May	Cutlass	12
Fert Appl	April	Cutlass	6
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvest Maize	July-Aug	Baskets/Bowls	11
Weed Cassava	September	Cutls	6
Weed Cs. - 2nd	December	Cutlass	6
Harvest Cassava	May		15
Total Labour Requirement			**88**

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Maize/Plantain

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	8
Tree Felling	March	Cutlass & Axe	6
Plant Maize	April	Line, Cutls, Hoe	7
Fert Appl	April	Cutlass	6
Plant Plantain	May	Cutls, Chissl, Hoe	16
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvest Maize	July	Baskets/Bowls	11
Weed Plantain	September	Cutls	6
Weed Plantain	Jan-Feb	Cutls	4
Harvest Plantain	Spread Out	Cutlass	10
Total Labour Requirement			**85**

Maize/Cassava/Plantain

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	8
Tree Felling	March	Cutlass & Axe	6
Plant Maize	April	Line, Cutls, Hoe	7
Plant Cassava	May	Cutlass	12
Fert Appl	April	Cutlass	6
Plant Plantain	May	Cutls, Chissl, Hoe	16
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvest Maize	July	Baskets/Bowls	11
Weed Pt & Cs	September	Cutls	8
Weed Pt & Cs	Jan-Feb	Cutls	6
Harvest Cassava	May	Baskets, Hoe	12
Harvest Plantain	Spread Out	Cutlass	9
Total Labour Requirement			**112**

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Maize/ Cassava/Cocoyam

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	8
Tree Felling	March	Cutlass & Axe	6
Plant Maize	April	Line, Cutls, Hoe	7
Plant Cassava	May	Cutlass	12
Fert Appl	April	Cutlass	6
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvest Maize	July	Baskets/Bowls	11
Weed Cs & Cy	September	Cutls	8
Weed Cs & Cy	Jan-Feb	Cutls	6
Harvest Cassava	May	Baskets, Hoe	12
Harvest Cocoyam	May-June	Hoe	5
Total Labour Requirement			**92**

Maize/Cassava/Cocoyam/Plantain

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	8
Tree Felling	March	Cutlass & Axe	6
Plant Maize	April	Line, Cutls, Hoe	7
Plant Cassava	May	Cutlass	12
Fert Appl	April	Cutlass	6
Plant Plantain	May	Cutls, Chissl, Hoe	16
1st Weeding	April	Hoe	7
2nd Weeding	May- June	Hoe/Cutlass	4
Harvest Maize	July	Baskets/Bowls	11
Weed Pt, Cs & Cy	September	Cutlass	8
Weed Pt, Cs & Cy	Jan-Feb	Cutlass	6
Harvest Cassava	May-June	Baskets, Hoe	12
Harvest Plantain	Spread Out	Cutlass	9
Harvest Cocoyam	May-June	Hoe	5
Total Labour Requirement			**117**

Cassava

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	10
Planting	April	Cutlass	12
1st Weeding	May	Hoe	12
2nd Weeding	July	Hoe/Cutlass	8
3rd Weeding	September	Cutlass	6
4th Weeding	January	Cutlass	3
Harvesting	May-June	Hoe/Cutlass	15
Total Labour Requirement			**66**

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Plantain

Activities	Month	Tools Used	Labour Days
Clearing	Jan-Feb	Cutls, Axe, Hoe	10
Planting	April	Cutls, Chissl, Hoe	18
1st Weeding	April	Hoe	12
2nd Weeding	May	Hoe/Cutlass	6
3rd Weeding	June	Cutlass	4
4th Weeding	July	Cutlass	3
Harvesting	Spread Out	Cutlass	12
Total Labour Requirement			**65**

Cowpea

Activities	Month	Tools Used	Labour Days
Clearing	July-August	Cutls, Hoe	9
Planting	August	Cutls,	6
1st Weeding	September	Hoe	6
2nd Weeding	October	Hoe/Cutlass	4
Harvesting	Nov-Dec	Baskets and Sacks	18
Total Labour Requirement			**43**

Pepper

Activities	Month	Tools Used	Labour Days
Clearing	March -April	Cutls, Axe, Hoe	9
Planting	May	Cutls, Hoe	7
Fert Appl	May	Hoe	2
Spraying	June	Spraying Mach.	2
1st Weeding	June	Hoe	6
2nd Weeding	July	Hoe/Cutlass	4
3rd Weeding	August	Hoe	3
Harvesting	Aug. - Sept.	Baskets and Sacks	15
Total Labour Requirement			**48**

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Tomatoes

Activities	Month	Tools Used	Labour Days
Clearing	March -April	Cutls, Axe, Hoe	10
Planting	May	Cutls, Hoe	7
Fert Appl	May	Hoe	2
Spraying	June	Spraying Mach.	3
1st Weeding	June	Hoe	5
2nd Weeding	July	Hoe	4
Harvesting	Aug. - Sept.	Baskets and Sacks	15
Total Labour Requirement			**46**

Garden-Eggs

Activities	Month	Tools Used	Labour Days
Clearing	March -April	Cutls, Axe, Hoe	10
Planting	May	Cutls, Hoe	7
Fert Appl	May	Hoe	2
Spraying	June	Spraying Mach.	3
1st Weeding	June	Hoe	5
2nd Weeding	July	Hoe/Cutlass	4
Harvesting	Aug. - Sept.	Baskets and Sacks	16
Total Labour Requirement			**47**

Garden-Eggs/Pepper

Activities	Month	Tools Used	Labour Days
Clearing	March -April	Cutls, Hoe	10
Plant Garden-Eggs	May	Cutls, Hoe	6
Plant Pepper	May	Cutls, Hoe	6
Fert Appl	May	Hoe	2
Spraying	June	Spraying Mach.	2
1st Weeding	June	Hoe	6
2nd Weeding	July	Hoe/Cutlass	4
3rd Weeding	August	Hoe (Pp)	3
Harvest Garden-Eggs	Aug. - Sept.	Baskets and Sacks	15
Harvest Pepper	Aug. - Sept.	Baskets and Sacks	13
Total Labour Requirement			**67**

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Garden-Eggs/Tomatoes

Activities	Month	Tools Used	Labour Days
Clearing	March -April	Cutls, Hoe	10
Plant Garden-Eggs	May	Cutls, Hoe	6
Plant Tomatoes	May	Cutls, Hoe	6
Fert Appl	May	Hoe	3
Spraying	April	Spraying Mach.	3
1st Weeding	June	Hoe	6
2nd Weeding	July	Hoe/Cutlass	4
Harvest Garden-Eggs	Aug. - Sept.	Baskets and Sacks	15
Harvest Tomatoes	Aug. - Sept.	Baskets and Sacks	13
Total Labour Requirement			**66**

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Appendix III

Crop Enterprise Budgets by Gender

Male Enterprises

Major Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			5292
Sub-Total			*20292*
Fertilizer (bags)	0.9	25000	22500
Labour-days	46	3000	138000
Total Variable Cost			180792
Output		*Price*	*Revenue*
Maize (Min. Bgs)	15	35000	525000
Gross Margin			**344208**

Minor Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			5292
Sub-Total			*20292*
Fertilizer (bags)	0.72	25000	18000
Labour-days	44	3000	132000
Total Variable Cost			170292
Output		*Price*	*Revenue*
Maize (Min. Bgs)	11.5	35000	402500
Gross Margin			**232208**

Female Enterprises

Major Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			4715
Sub-Total			19715
Fertilizer (bags)	1	25000	25000
Labour-days	46	3000	138000
Total Variable Cost			182715
Output		*Price*	*Revenue*
Maize (Min. Bgs)	13.5	35000	472500
Gross Margin			**289785**

Minor Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			4715
Sub-Total			19715
Fertilizer (bags)	0.8	25000	20000
Labour-days	44	3000	132000
Total Variable Cost			171715
Output		*Price*	*Revenue*
Maize (Min. Bgs)	10.5	35000	367500
Gross Margin			**195785**

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Male Enterprises

Maize/ Cassava

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			10332
Sub-Total			*55332*
Fertilizer (bags)	0.9	25000	52500
Labour-days	88	3000	264000
Total Variable Cost			371832
Output		*Price*	
Maize (Mini-Bags)	12.5	35000	437500
Cassava	17	22000	374000
Total revenue			811500
Gross Margin			**439668**

Female Enterprises

Maize/ Cassava

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			9205
Sub-Total			*54205*
Fertilizer (bags)	1	25000	30000
Labour-days	88	3000	264000
Total Variable Cost			348205
Output		*Output price*	
Maize (Mini-Bags)	11.5	35000	402500
Cassava	18	22000	396000
Total revenue			798500
Gross Margin			**450295**

Maize/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Plantain Suckers	600	150	180000
Tool Cost			9324
Sub-Total			*204324*
Fertilizer (bags)	0.9	25000	52500
Labour-days	85	3000	255000
Total Variable Cost			511824
Output		*Price*	
Maize (Mini-Bags)	12.5	35000	437500
Plantain (Bundles)	220	4000	880000
Total revenue			1317500
Gross Margin			**805676**

Maize/ Plantain

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Plantain Suckers	600	150	180000
Tool Cost			8307
Sub-Total			*203307*
Fertilizer (bags)	1	25000	30000
Labour-days	85	3000	255000
Total Variable Cost			488307
Output		*Price*	
Maize (Mini-Bags)	11.5	35000	402500
Plantain (Bundles)	210	4000	840000
Total revenue			1242500
Gross Margin			**754193**

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Male Enterprises

Maize/Cassava/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Tool Cost			10332
Sub-Total			235332
Fertilizer (bags)	0.9	25000	52500
Labour-days	112	3000	336000
Total Variable Cost			623832
Output		*Price*	
Maize (Mini-Bags)	12.5	35000	437500
Cassava	17	22000	374000
Plantain Output	150	4000	600000
Total revenue			1411500
Gross Margin			**787668**

Maize/Cassava/ Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Cocoyam suckers	Voluntary germination		
Tool Cost			10332
Sub-Total			55332
Fertilizer (bags)	0.9	25000	52500
Labour-days	92	3000	276000
Total Variable Cost			383832
Output		*Price*	
Maize (Mini-Bags)	12.5	35000	437500
Cassava	17	22000	374000
Cocoyam	12	15000	180000
Total revenue			991500
Gross Margin			**607668**

Female Enterprises

Maize/Cassava/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Tool Cost			9205
Sub-Total			234205
Fertilizer (bags)	1	25000	30000
Labour-days	112	3000	336000
Total Variable Cost			600205
Output		*Price*	
Maize (Mini-Bags)	11.5	35000	402500
Cassava	18	22000	396000
Plantain Output	160	4000	640000
Total revenue			1438500
Gross Margin			**838295**

Maize/Cassava/ Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Cocoyam suckers	Voluntary germination		
Tool Cost			9205
Sub-Total			54205
Fertilizer (bags)	1	25000	30000
Labour-days	92	3000	276000
Total Variable Cost			360205
Output		*Price*	
Maize (Mini-Bags)	11.5	35000	402500
Cassava	18	22000	396000
Cocoyam	18	15000	270000
Total revenue			1068500
Gross Margin			**708295**

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Male Enterprises

Maize/Cassava/Plantain/Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Cocoyam suckers	Voluntary germination		
Tool Cost			10332
Sub-Total			235332
Labour-days	117	3000	351000
Fertilizer (bags)	0.9	25000	52500
Total Variable Cost			638832
Output		*Price*	
Maize (Min. Bgs)	12.5	35000	437500
Cassava	17	22000	374000
Plantain (Bundles)	150	4000	600000
Cocoyam	12	15000	180000
Total revenue			1591500
Gross Margin			**952668**

Female Enterprises

Maize/Cassava/Plantain/Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Cocoyam suckers	Voluntary germination		
Tool Cost			9205
Sub-Total			234205
Labour-days	117	3000	351000
Fertilizer (bags)	1	25000	30000
Total Variable Cost			615205
Output		*Price*	
Maize (Min. Bgs)	11.5	35000	402500
Cassava	18	22000	396000
Plantain (Bundles)	160	4000	640000
Cocoyam	18	15000	270000
Total revenue			1708500
Gross Margin			**1093295**

Cassava

Item	Quantity	Unit Price	Total
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			10080
Sub-Total			40080
Labour-days	66	3000	198000
Total Variable Cost			238080
Output		*Price*	
Cassava	20	22000	440000
Gross Margin			**201920**

Cassava

Item	Quantity	Unit Price	Total
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			8980
Sub-Total			38980
Labour-days	66	3000	198000
Total Variable Cost			236980
Output		*Price*	
Cassava	23	22000	506000
Gross Margin			**269020**

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Male Enterprises

Plantain

Item	Quantity	Unit Price	Total
Plantain Suckers	600	150	180000
Tool Cost			8064
Sub-Total			188064
Labour-days	65	3000	195000
Total Variable Cost			383064
Output		*Price*	*Revenue*
Plantain (bundles)	240	4000	960000
Gross Margin			**576936**

Pepper

Item	Quantity	Unit Price	Total
Pepper seed	4 cups	5000	20000
Tool Cost			1512
Sub-Total			21512
Labour-days	48	3000	144000
Fertilizer (bags)	0.27	25000	6750
Total Variable Cost			172262
Output		*Price*	*Revenue*
Pepper (Min Bg)	24	15000	360000
Gross Margin			**187738**

Cowpea

Item	Quantity	Unit Price	Total
Seed (Kilos)	5.5	3200	17600
Tool Cost			4910
Sub-Total			22510
Labour-days	43	3000	129000
Total Variable Cost			151510
Output		*Price*	*Revenue*
Cowpea - Minibags	5	60000	300000
Gross Margin			**148490**

Female Enterprises

Plantain

Item	Quantity	Unit Price	Total
Plantain Suckers	600	150	180000
Tool Cost			5920
Sub-Total			185920
Labour-days	65	3000	195000
Total Variable Cost			380920
Output		*Price*	*Revenue*
Plantain (Bundles)	230	4000	920000
Gross Margin			**539080**

Pepper

Item	Quantity	Unit Price	Total
Pepper seed	4 cups	5000	20000
Tool Cost			1347
Sub-Total			21347
Labour-days	48	3000	144000
Fertilizer (bags)	0.3	25000	7500
Total Variable Cost			172847
Output		*Price*	*Revenue*
Pepper (Min Bg)	34	15000	510000
Gross Margin			**337153**

Cowpea

Item	Quantity	Unit Price	Total
Seed (Kilos)	5.5	3200	17600
Tool Cost			4250
Sub-Total			21850
Labour-days	43	3000	129000
Total Variable Cost			150850
Output		*Price*	*Revenue*
Cowpea - Minibags	6	60000	360000
Gross Margin			**209150**

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Male Enterprises

Tomatoes

Item	Quantity	Unit Price	Total
Tomato Seed			20000
Other Costs			15000
Tool Cost			2016
Sub-Total			37016
Labour-days	46	3000	138000
Fertilizer (bags)	0.45	25000	11250
Total Variable Cost			186266
Output		*Price*	
Tomatoes (crates)	45	15000	675000
Gross Margin			**488734**

Garden Eggs

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2016
Sub-Total			52016
Labour-days	47	3000	141000
Fertilizer (bags)	0.45	25000	11250
Total Variable Cost			204266
Output		*Price*	*Revenue*
GE (minibags)	160	13000	2080000
Gross Margin			**1875734**

Female Enterprises

Tomatoes

Item	Quantity	Unit Price	Total
Tomato Seed			20000
Other Costs			15000
Tool Cost			1796
Sub-Total			36796
Labour-days	46	3000	138000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			187296
Output		*Price*	
Tomatoes (crates)	56	15000	840000
Gross Margin			**652704**

Garden-Eggs

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1796
Sub-Total			51796
Labour-days	47	3000	141000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			205296
Output		*Price*	*Revenue*
GE (minibags)	60	13000	780000
Gross Margin			**574704**

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Male Enterprises

Garden-Eggs/Pepper

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2016
Sub-Total			72016
Labour-days	67	3000	201000
Fertilizer (bags)	0.45	25000	11250
Total Variable Cost			284266
Output		*Price*	
GE (minibags)	115	13000	1495000
Pepper (Min Bg)	18	15000	270000
Total revenue			1765000
Gross Margin			**1480734**

Garden-Eggs/Tomatoes

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2336
Sub-Total			72336
Labour-days	66	3000	198000
Fertilizer (bags)	0.45	25000	11250
Total Variable Cost			281586
Output		*Price*	
GE (minibags)	115	13000	1495000
Tomatoes (crates)	40	15000	600000
Total revenue			2095000
Gross Margin			**1813414**

Female Enterprises

Garden-Eggs/Pepper

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1796
Sub-Total			71796
Labour-days	67	3000	201000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			285296
Output		*Price*	
GE (minibags)	52	13000	676000
Pepper (mini-bags)	25	15000	375000
Total revenue			1051000
Gross Margin			**765704**

Garden-Eggs/Tomatoes

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1576
Sub-Total			71576
Labour-days	66	3000	198000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			282076
Output		*Price*	
GE (minibags)	52	13000	676000
Tomatoes (crates)	52		780000
		15000	
Total revenue			1456000
Gross Margin			**1173924**

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Appendix IV
Crop Enterprise Budgets by Agricultural Assistance

Farmers With Agricultural Assistance

Major Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			6132
Sub-Total			*21132*
Fertilizer (bags)	1.3	25000	32500
Labour-days	46	3000	138000
Total Variable Cost			191632
Output		*Price*	*Revenue*
Maize (Mini-Bags)	13.5	35000	472500
Gross Margin			**280868**

Minor Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			6132
Sub-Total			*21132*
Fertilizer (bags)	1.04	25000	26000
Labour-days	44	3000	132000
Total Variable Cost			179132
Output		*Price*	*Revenue*
Maize (Mini-Bags)	10	38000	380000
Gross Margin			**200868**

Farmers Without Agricultural Assistance

Major Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			4137
Sub-Total			19137
Fertilizer (bags)	1	25000	25000
Labour-days	46	3000	138000
Total Variable Cost			182137
Output		*Price*	*Revenue*
Maize (Mini-Bags)	11.5	35000	402500
Gross Margin			**220363**

Minor Season Maize

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Tool Cost			4137
Sub-Total			19137
Fertilizer (bags)	0.8	25000	20000
Labour-days	44	3000	132000
Total Variable Cost			171137
Output		*Price*	*Revenue*
Maize (Mini-Bags)	8.5	38000	323000
Gross Margin			**151863**

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Farmers With Agricultural Assistance

Maize/ Cassava

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			11972
Sub-Total			*56972*
Fertilizer (bags)	1.3	25000	52500
Labour-days	88	3000	264000
Total Variable Cost			373472
Output		*Price*	
Maize (Mini-Bags)	12	35000	420000
Cassava	18	22000	396000
Total revenue			816000
Gross Margin			**442528**

Farmers Without Agricultural Assistance

Maize/ Cassava

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			8077
Sub-Total			*53077*
Fertilizer (bags)	1	25000	30000
Labour-days	88	3000	264000
Total Variable Cost			347077
Output		*Output price*	
Maize (Mini-Bags)	10	35000	350000
Cassava	17	22000	374000
Total revenue			724000
Gross Margin			**376923**

Maize/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Plantain Suckers	600	150	180000
Tool Cost			10804
Sub-Total			*205804*
Fertilizer (bags)	1.3	25000	52500
Labour-days	85	3000	255000
Total Variable Cost			513304
Output		*Price*	
Maize (Mini-Bags)	12	35000	420000
Plantain (Bundles)	135	4000	540000
Total revenue			960000
Gross Margin			**446696**

Maize/ Plantain

Item	Quantity	Unit Price	Total
Seed (Kilos)	5	3000	15000
Plantain Suckers	600	150	180000
Tool Cost			7289
Sub-Total			*202289*
Fertilizer (bags)	1	25000	30000
Labour-days	85	3000	255000
Total Variable Cost			487289
Output		*Price*	
Maize (Mini-Bags)	10	35000	350000
Plantain (Bundles)	215	4000	860000
Total revenue			1210000
Gross Margin			**722711**

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Farmers With Agricultural Assistance

Maize/Cassava/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Tool Cost			11972
Sub-Total			236972
Fertilizer (bags)	1.3	25000	52500
Labour-days	112	3000	336000
Total Variable Cost			625472
Output		*Price*	
Maize (Mini-Bags)	12	35000	420000
Cassava	18	22000	396000
Plantain Output	112	4000	448000
Total revenue			1264000
Gross Margin			**638528**

Farmers Without Agricultural Assistance

Maize/Cassava/ Plantain

Item	Quantity	Unit Price	Total
Maize Seed (kilos)	5	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Tool Cost			8077
Sub-Total			233077
Fertilizer (bags)	1	25000	30000
Labour-days	112	3000	336000
Total Variable Cost			599077
Output		*Price*	
Maize (Mini-Bags)	10	35000	350000
Cassava	17	22000	374000
Plantain Output	154	4000	616000
Total revenue			990000
Gross Margin			**390923**

Maize/Cassava/ Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Cocoyam suckers	Voluntary germination		
Tool Cost			11972
Sub-Total			56972
Labour-days	92	3000	276000
Fertilizer (bags)	1.3	25000	52500
Total Variable Cost			385472
Output		*Price*	
Maize (Mini-Bags)	12	35000	420000
Cassava	18	22000	396000
Cocoyam	12.5	15000	187500
Total revenue			1003500
Gross Margin			**618028**

Maize/Cassava/ Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Cocoyam suckers	Voluntary germination		
Tool Cost			8077
Sub-Total			53077
Labour-days	92	3000	276000
Fertilizer (bags)	1	25000	30000
Total Variable Cost			359077
Output		*Price*	
Maize (Mini-Bags)	10	35000	350000
Cassava	17	22000	374000
Cocoyam	12.5	15000	187500
Total revenue			911500
Gross Margin			**552423**

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Farmers With Agricultural Assistance

Maize/Cassava/Plantain/Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Cocoyam suckers	Voluntary germinatio n		
Tool Cost			11972
Sub-Total			236972
Labour-days	117	3000	351000
Fertilizer (bags)	1.3	25000	52500
Total Variable Cost			640472
Output		*Price*	
Maize (Mini-Bags)	12	35000	420000
Cassava	18	22000	396000
Plantain (Bundles)	112	4000	448000
Cocoyam	12.5	15000	187500
Total revenue			1451500
Gross Margin			**811028**

Cassava

Item	Quantity	Unit Price	Total
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			11680
Sub-Total			41680
Labour-days	66	3000	198000
Total Variable Cost			239680
Output		*Price*	
Cassava	23	22000	506000
Gross Margin			**266320**

Farmers Without Agricultural Assistance

Maize/Cassava/Plantain/Cocoyam

Item	Quantity	Unit Price	Total
Maize Seed	5 kilos	3000	15000
Cassava Sticks	6 hdlds	2500	30000
Plantain Suckers	600	150	180000
Cocoyam suckers	Voluntary germinatio n		
Tool Cost			8077
Sub-Total			233077
Labour-days	117	3000	351000
Fertilizer (bags)	1	25000	30000
Total Variable Cost			614077
Output		*Price*	
Maize (Mini-Bags)	10	35000	350000
Cassava	17	22000	374000
Plantain (Bundles)	154	4000	616000
Cocoyam	12.5	15000	187500
Total revenue			1527500
Gross Margin			**913423**

Cassava

Item	Quantity	Unit Price	Total
Cassava Sticks	6 hdlds	2500	30000
Tool Cost			7880
Sub-Total			37880
Labour-days	66	3000	198000
Total Variable Cost			235880
Output		*Price*	
Cassava	24	22000	528000
Gross Margin			**292120**

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Farmers With Agricultural Assistance

Plantain

Item	Quantity	Unit Price	Total
Plantain Suckers	600	150	180000
Tool Cost			9344
Sub-Total			189344
Labour-days	65	3000	195000
Total Variable Cost			384344
Output		*Price*	*Revenue*
Plantain (bundles)	150	4000	600000
Gross Margin			**215656**

Farmers Without Agricultural Assistance

Plantain

Item	Quantity	Unit Price	Total
Plantain Suckers	600	150	180000
Tool Cost			6304
Sub-Total			186304
Labour-days	65	3000	195000
Total Variable Cost			381304
Output		*Price*	*Revenue*
Plantain (Bundles)	225	4000	900000
Gross Margin			**518696**

Pepper

Item	Quantity	Unit Price	Total
Pepper seed	4 cups	5000	20000
Tool Cost			1752
Sub-Total			21752
Labour-days	48	3000	144000
Fertilizer (bags)	0.39	25000	9750
Total Variable Cost			175502
Output		*Price*	*Revenue*
Pepper (Min Bg)	40	15000	600000
Gross Margin			**424498**

Pepper

Item	Quantity	Unit Price	Total
Pepper seed	4 cups	5000	20000
Tool Cost			1182
Sub-Total			21182
Labour-days	48	3000	144000
Fertilizer (bags)	0.3	25000	7500
Total Variable Cost			172682
Output		*Price*	*Revenue*
Pepper (Min Bg)	45	15000	675000
Gross Margin			**502318**

Cowpea

Item	Quantity	Unit Price	Total
Seed (Kilos)	5.5	3200	17600
Tool Cost			5346
Sub-Total			22946
Labour-days	43	3000	129000
Total Variable Cost			151946
Output		*Price*	*Revenue*
Cowpea - Minibags	6	60000	360000
Gross Margin			**208054**

Cowpea

Item	Quantity	Unit Price	Total
Seed (Kilos)	5.5	3200	17600
Tool Cost			3952
Sub-Total			21552
Labour-days	43	3000	129000
Total Variable Cost			150552
Output		*Price*	*Revenue*
Cowpea - Minibags	4	60000	240000
Gross Margin			**89448**

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Farmers With Agricultural Assistance

Tomatoes

Item	Quantity	Unit Price	Total
Tomato Seed			20000
Other Costs			15000
Tool Cost			2336
Sub-Total			37336
Labour-days	46	3000	138000
Fertilizer (bags)	0.65	25000	16250
Total Variable Cost			191586
Output		*Price*	
Tomatoes (crates)	42	24000	1008000
Gross Margin			**816414**

Farmers Without Agricultural Assistance

Tomatoes

Item	Quantity	Unit Price	Total
Tomato Seed			20000
Other Costs			15000
Tool Cost			1576
Sub-Total			36576
Labour-days	46	3000	138000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			187076
Output		*Price*	
Tomatoes (crates)	53	24000	1272000
Gross Margin			**1084924**

Garden Eggs

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2336
Sub-Total			52336
Labour-days	47	3000	141000
Fertilizer (bags)	0.65	25000	16250
Total Variable Cost			209586
Output		*Price*	*Revenue*
GE (minibags)	145	13000	1885000
Gross Margin			**1675414**

Garden-Eggs

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1576
Sub-Total			51576
Labour-days	47	3000	141000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			205076
Output		*Price*	*Revenue*
GE (minibags)	120	13000	1560000
Gross Margin			**1354924**

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Farmers With Agricultural Assistance

Garden-Eggs/Pepper

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2336
Sub-Total			72336
Labour-days	67	3000	201000
Fertilizer (bags)	0.65	25000	16250
Total Variable Cost			289586
Output		*Price*	
GE (minibags)	85	13000	1105000
Pepper (Min Bg)	32	15000	480000
Total revenue			1585000
Gross Margin			**1295414**

Farmers Without Agricultural Assistance

Garden-Eggs/Pepper

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1576
Sub-Total			71576
Labour-days	67	3000	201000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			285076
Output		*Price*	
GE (minibags)	95	13000	1235000
Pepper (mini-bags)	24	15000	360000
Total revenue			1595000
Gross Margin			**1309924**

Garden-Eggs/Tomatoes

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			2336
Sub-Total			72336
Labour-days	66	3000	198000
Fertilizer (bags)	0.65	25000	16250
Total Variable Cost			286586
Output		*Price*	
GE (minibags)	85	13000	1105000
Tomatoes (crates)	34	24000	816000
Total revenue			1921000
Gross Margin			**1634414**

Garden-Eggs/Tomatoes

Item	Quantity	Unit Price	Total
G-Egg seed	4 cups	5000	20000
Pepper seed	4 cups	5000	20000
Other Costs			30000
Tool Cost			1576
Sub-Total			71576
Labour-days	66	3000	198000
Fertilizer (bags)	0.5	25000	12500
Total Variable Cost			282076
Output		*Price*	
GE (minibags)	95	13000	1235000
Tomatoes (crates)	29	24000	696000
Total revenue			1931000
Gross Margin			**1648924**

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Appendix V: Simulation Results

Simulation Results for Male Farmers

	Base	*Increase in Rented Land*	*Hired Labour*	*Credit*	*Increased Maize Yield*
Objective Function Value	9,388,682.21	9,388,682.21	9,388,682.21	10,146,630.90	10,976,929.11
Change in Income		*0.0*	*0.0*	*757,948.7*	*1,588,246.9*
Elasticities		0.0	0.0	0.068	0.423
Major Maize	2.1	2.1	2.1	3.7	3.2
Minor Maize	5	5	5	6.7	4.4
M/Cs					
M/Pt					0.04
M/Cs/Pt					
M/Cs/Cy					
M/Cs/Pt/Cy	0.97	0.97	0.97	0.7	0.9
Cs					
Pt					
Pp					
Cowpea					
Tm					
GE	3	3	3	3	3
GE/Pp					
Buy Fert Major	4.1	4.1	4.1	4.8	5
Buy Fert Major	3.6	3.6	3.6	3	3.1
Rent Lnd - Mj	2.1	2.1	2.1	3	3
Rent Lnd - Mn	1.9	1.9	1.9	3	1.2
Bor. Cap - Major	361905.6	361905.6	361905.6	747939.9	355672
Bor. Cap - Minor	188094.5	188094.5	188094.5	444566.8	194327.7
Cap Repayment	550000	550000	550000	1192506.7	550000
Sell Mj Maize				7493.3	76.6
Sell Mn Maize					
Store Mj Maize	39.8	39.8	39.8	59.2	2
Store Mn Maize	53.5	53.5	53.5	73	67.2
Sell Mj. Store Maize	37.8	37.8	37.8	57.2	
Sell Mn. Store Maize	50.5	50.5	50.5	70	64.2
Sell Cassava	6.6	6.6	6.6	1.5	4.9
Sell Plantain	6.1	6.1	6.1	0	
Sell Cocoyam	11.7	11.7	11.7	8.1	10.5
Sell Pepper					
Sell Cowpea					
Sell Tomatoes					
Sell G-Eggs	480	480	480	480	480
Purchase Maize	0	0	0	0	0
Purchase Cassava	0	0	0	0	0
Purchase Plantain	0	0	0	39 bunches	0

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Simulation Results for Female Farmers

	Base Model	*Increase in Rented Land*	*Hired Labour*	*Credit*	*Increased Maize Yield*
Objective Function Value	4,408,808.0	4,962,783.0	4,408,808.0	4,539,821.7	5,317,057.0
Change in Income		553,975.0	0.0	131,013.7	908,249.0
Elasticities		0.126	0.0	0.0	0.010
Major Maize	1.3	1.5	1.3	2	1.3
Minor Maize	3.3	1	3.3	4	3.3
M/Cs					
M/Pt					
M/Cs/Pt					
M/Cs/Cy		0.8			
M/Cs/Pt/Cy	0.9	0.9	0.9	0.5	0.9
Cs					
Pt					
Pp					
Cowpea		2.7			
Tm	2	2	2	2	2
GE					
GE/Pp					
Buy Fert Major	3.1	4.1	3.1	3.5	3.1
Buy Fert Major	2.6	0.8	2.6	3.2	2.6
Rent Lnd - Mj	2	3.7	2	2	2
Rent Lnd - Mn	2	4	2	2	2
Bor. Cap - Major	159051.3	230738.8	159051.3	374875	127290.1
Bor. Cap - Minor	140948.8	69261.2	140948.8	194360	172709.9
Cap Repayment	300000	300000	300000	569235	300000
Sell Mj Maize	9.7	31.7	9.7		30.8
Sell Mn Maize		4.4			3.1
Store Mj Maize	12.6	2	12.6	27.8	2
Store Mn Maize	30.6	3	30.6	38.5	41.2
Sell Mj. Store Maize	10.6		10.6	25.75	
Sell Mn. Store Maize	27.6		27.6	35.5	38.2
Sell Cassava	5.8	19.3	5.8		5.8
Sell Plantain					
Sell Cocoyam	15.8	29.3	15.8	9	15.8
Sell Pepper					
Sell Cowpea		16.2			
Sell Tomatoes	112	112	112	112	112
Sell G-Eggs					
Purchase Maize	0	0	0	0	0
Purchase Cassava	0	0	0	0	0
Purchase Plantain	0	0	0	60 bunches	0

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Simulation Results for Farmers with Agricultural Assistance

	Base Model	*Increase in Rented Land*	*Hired Labour*	*Credit*	*Maize Yield*
Objective Function Value	7,124,265.3	7,124,265.3	7,124,265.3	8,018,776.5	8,147,223.0
Change in Income				894,511.2	1,022,957.7
Elasticities		0	0	0.09	0.36
Activity Levels					
Major Maize	1.5	1.5	1.5	2.7	1.5
Minor Maize	3.1	3.1	3.1	5.7	3.1
M/Cs	0.6	0.6	0.6	0.6	0.6
M/Pt	1	1	1	0.6	1
Cs					
Pt					
Pp					
Cowpea	0.6	0.6	0.6		0.6
Tm					
GE	3	3	3	3	3
Buy Fert Major	7.1	7.1	7.1	8.1	7.1
Buy Fert Major	2	2	2	3.7	2
Rent Lnd - Mj	2.7	2.7	2.7	3	2.7
Rent Lnd - Mn	1.95	1.95	1.95	3	1.95
Bor. Cap - Major	330633	330633	330633	813208	330633
Bor. Cap - Minor	69367	69367	69367	386792	69367
Cap Repayment	400000	400000	400000	1200000	400000
Sell Mj Maize	33.1	33.1	33.1		48.8
Sell Mn Maize	8.2	8.2	8.2		20.7
Store Mj Maize	2	2	2	46.5	2
Store Mn Maize	19.6	19.6	19.6	53.8	19.6
Sell Mj. Store Maize				44.5	
Sell Mn. Store Maize	16.6	16.6	16.6	50.8	16.6
Sell Cassava					
Sell Plantain					
Sell Cocoyam					
Sell Pepper					
Sell Cowpea	3.8	3.8	3.8		3.8
Sell Tomatoes					
Sell G-Eggs	435	435	435	435	435
Purchase Maize	0	0	0	0	0
Purchase Cassava	0	0	0	0	0
Purchase Plantain	0	0	0	62 bunches	0

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Simulation Results for Farmers with No Agricultural Assistance

	Base Model	*Incr Rented Land*	*Hired Labour*	*Credit*	*Maize Yield*
Objective Function Value	5,307,441.9	5,359,295.0	5,314,510.0	5,377,925.8	6,185,318.8
		51,853.1	7,068.1	70,483.9	877,876.9
Elasticity		0.01	0.001	0.011	0.414
Major Maize	0.7	0.1	0.6	1.4	1.5
Minor Maize	2.7	2.1	2.6	3.4	4.1
M/Cs					
M/Pt	0.6	1.6	0.6		0.2
M/Cs/Pt					
M/Cs/Pt/Cy	1.1	0.6	1.2	1.3	0.7
Cs					
Pt					
Pp					
Cowpea		0.2			
Tm					
GE					
GE/Tm	2	2	2	2	2
Buy Fert Major	3.3	3.2	3.3	3.7	3.3
Buy Fert Major	2.1	1.6	2	2.7	3.2
Rent Lnd - Mj	2	2.4	2	2	1.2
Rent Lnd - Mn	2	2.6	2	2	1.7
Bor. Cap - Major	488925	500000	495612	560230	323364
Bor. Cap - Minor	11075		4388	66601	176636
Cap Repayment	500000	500000	500000	626831	500000
Sell Mj Maize					
Sell Mn Maize					
Store Mj Maize	20.3	18.3	19.6	25.3	31.6
Store Mn Maize	19.1	14	18.2	25.7	44.8
Sell Mj. Store Maize	18.2	16.3	17.6	23.3	29.6
Sell Mn. Store Maize	16.1	11	15.2	22.7	41.8
Sell Cassava	7.9		9.8	11.8	1.2
Sell Plantain	155.4	290.2	159.8	57.5	0
Sell Cocoyam	13.2	7.4	14.5	16	8.2
Sell Pepper					
Sell Cowpea		0.9			
Sell Tomatoes	58	58	58	58	58
Sell G-Eggs	190	190	190	190	190
Purchase Maize	0	0	0	0	0
Purchase Cassava	0	0	0	0	0
Purchase Plantain	0	0	0	0	0