Cost minimisation for cassava production in the Transition and Forest Agro-Ecological zones, Ghana

Jonas Osei-Adu

DECLARATION

I, Jonas Osei-Adu, the author of this thesis titled "Cost minimisation for cassava production in the Transition and Forest Agro-Ecological zones, Ghana" do hereby declare that, except for references of other people's work duly cited, this work was done by me in the Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi.

I further declare this work has never been presented either in whole or part for any degree in this University or elsewhere.

…………………………………..

Jonas Osei-Adu

(Student)

……………………………………

Mr. Fred Nimoh

(Supervisor)

……………………………………..

Dr.S.C Fialor

(Head of Department)

DEDICATION

This work is dedicated to my parents Mr. John Osei-Anane and Late Mrs. Margret Osei and my siblings Comfort, Paulina, Mary and Assibey whose sacrifice, love, care and support have brought me this far.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to God Almighty for his guidance and protection in completing this work.

My sincere thanks also go to the West African Agricultural Productivity Programme (WAAPP) for awarding me a fellowship in pursuing my programme and completion of this work.

My supervisors, Mr.Fred Nimoh and Nana Osei-Agyemang cannot be forgotten for their advice, suggestions and words of encouragement in making this work a reality. I will forever be indebted to them.

My appreciation also goes to my uncles Mr. Enouch Ohemeny, Issac Ohenemeng Gyebi and Prof Charles F. Yamoah.

Many thanks go to the entire staff of CSIR-Crops Research Institute for their support and prayers. Special thanks go to the Director Dr .Hans Adu Dapaah, Dr.A.A Dankyi, Benedicta Nsiah Frimpong, Bright Asante, Mrs Haleegoah, Mrs Acheampong, Miss Ankomah, Adu-Appiah, Mrs Brobbery, Mrs Yeboah, Mr. Amoah, Asiamah, Gregory, Sarfo, Victoria, Mary and all who contributed to the success of this work.

My course mates Gideon, Mr. Prah, Tansie and the entire 2008 Post-graduate Agricultural Economics class is appreciated for their support and suggestions.

My siblings Comfort, Paulina, Mary, Assibey, my nephews and niece (Isaac Snr and Jnr, Akuwe and Jane) cannot be forgotten for their prayers and support.

My dearest Ivy Efua Dolpnine is also appreciated for been by my side, especially in difficult times with her words of encouragement and useful suggestions.

ABSTRACT

Despite the important role cassava plays in the economy as food security and income generation crop, its development has been faced by a number of challenges. Prominent among these challenges is the high cost of production emanating from cost of stem cuttings (planting material), harvesting and transportation. This study was therefore undertaken to find out how farmers can minimise cost of production through an optimal expenditure approach on activities of production. Knowing the major activities of production and how much should be spent on each activity to minimise total cost of production is a key step in reducing cost of production.

Data was collected from the Eastern and Brong Ahafo regions which are the two major cassava producing regions in Ghana representing the Forest and Transition zones respectively. Multi-stage sampling was used in selecting two Municipals from each region. Suhum/Kraboa/Coaltar and West Akim Municipals were selected for the Eastern Region and Techiman and Wenchi Municipals for the Brong Ahafo Region. Classical optimisation theory was used to investigate whether farmers in the Transition and Forest agro-ecological zones operate at minimal cost. Boarded Hessian determinants through the use of Laplace expansion was applied to estimate the optimal levels of expenditure and total cost of production as well as cost at major activity levels. From the study, it was realised that cassava farmers in the study area were cost minimisers. They were however not operating at the optimal expenditure levels which curtail their ability to further reduce cost. For them to operate at the optimal level, they need to cut down on activity expenditure for land preparation, planting, farm maintenance and harvest and post-harvest and increase expenditure on fixed inputs.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AVC	Average Variable Cost
ATC	Average Total Cost
AFC	Average Fixed Cost
BLUE	Best Linear Unbiased Estimator
CBA	Cost Benefit Analysis
CUA	Cost Utility Analysis
CEA	Cost Effective Analysis
CMA	Cost Mininisation Analysis
ESPD	Economic Social Policy Department
FAO	Food and Agriculture Organisation
GSS	Ghana Statistical Service
GLSS	Ghana Living Standards Survey
GOG	Government of Ghana
GHC	Ghana Cedis
GDP	Gross Domestic Product
ILO	International Labour Organisation
IFPRI	International Food Policy Research Institute
MC	Marginal Cost
MoFA	Ministry of Food and Agriculture
OLS	Ordinary Least Square
PBS	Programme for Biosaftey Systems
RTIP	Root and Tuber Improvement Programme
SRID	Statistics, Research and Information Directorate
TFC	Total Fixed Cost
TVC	Total Variable Cost
TC	Total Cost
TNHC	Total National Holders Cultivating
UNDP	United Nations Development Programme

CHAPTER ONE

INTRODUCTION

1.1 Background

Cassava is one of the most important food crops in Ghana. Together with yam, they occupy an important position in Ghana's agricultural economy and contribute about 46% of agricultural Gross Domestic Product (GDP). Cassava accounts for a daily calorie intake of 30% in Ghana and is grown by nearly every farming family (FAO, 2000). Average area cropped per year between 1999 and 2004 was about 750,000 hectares, yielding about 10 million metric tons (IFPRI and PBS, 2007). This did increase in 2005 to 921,450 ha, ranking second to maize of 966,478 ha (SRID-MoFA, 2006).

However, cassava has been superior in terms of total production and yield. Total production for 2009 was 12,231,000 MT/ha as compared to Maize 1,620,000 MT/ha which was leading in terms of land under cultivation. Average yield per ha for 2009 was 13.8Mt/ha while that of maize was 1.7 Mt/ha (MoFA, 2009) clearly putting cassava above its competitors.

Cassava is produced in almost every region in Ghana. The bulk of the nation's cassava is produced in the south and middle of Ghana, which accounts for roughly 78% of the total cassava production in Ghana. (FAO, 2000). The leading cassava producing region in Ghana is the Eastern region in terms of volume with 4, 310,11 1 MT. This is followed by the Brong Ahafo and Ashanti regions with 3,481,273 MT and 1,613,607 MT respectively (SRID-MoFA, 2006).

1.1.1 Origin and Use of Cassava

Cassava (*Manihot esculenta Crantz*) was introduced in Ghana and Africa between the 16th and 17th century by Portuguese traders who travelled along the African Coast and Brazil (Jones, 1959). This crop was grown in Ghana (formerly Gold Coast) around the Portuguese's trading ports, forts and castles and it was a principal food eaten by both the Portuguese and slaves. By the second half of the 18th century, cassava had become the most widely grown and used crop of the people of the coastal plains (Adams, 1957).

Cassava as a food security crop can be used in various forms. It can be eaten raw by cooking, pounded into fufu or semi-processed. Some processed forms include, gari, tapioca and flour for konkonte. It is also used as animal feed.

1.1.2 Contribution of Cassava to Economic Development

Cassava's contribution to the national economy and development is enormous. This is demonstrated by the number of households involved in its production. According to the 1987/88 Ghana Living Standards Surveys (GLSS), 1.73 million sampled households (83 percent) were engaged in cassava production (GSS, 1987). Its contribution to AGDP in 1998 was 22% (FAO, 2000). It is also a source of employment, explaining why it was adopted under the presidential initiatives to solve the problem of underemployment and unemployment in the country (GOG, ILO and UNDP, 2004). Its nutritional content cannot be over emphasised. Its roots are rich in energy and the leaves provide vitamin A and C as well as protein. This explains why it was able to help reduce the prevalence of undernourishment by more than 30 percentage points between 1979-81 and 1996-98. Most Ghanaians use cassava as their source of carbohydrate and inexpensive source of food energy eaten by all social classes (FAO-ESPD, 2000)

1.2 Problem Statement

Despite the important role cassava plays in the economy as food security and income generation crop, its development is faced by a number of challenges. Prominent among these challenges is the high cost of production emanating from cost of stem cuttings, harvesting and transportation (RTIP, 2004).

In a paper under a sub heading "Constrains to Cassava Production" the IFPRI and PBS (2007) stated while cassava production demands few external inputs, labour and planting materials are the main costs of production. As a root crop, cassava requires a lot of labour to harvest. The production of cassava is dependent on the supply of good quality stem cuttings. The multiplication rate of these vegetative planting materials is very low compared to grain crops, which are propagated by true seeds. Cassava stem cuttings are bulky and highly perishable, drying up within a few days. Cost of clean stem cuttings is very high. Clean stem cuttings are scare due to the presence of Cassava Mosaic Virus (CMV) disease through out the country. This is due to the vegetative nature of propagation such that the disease is transmitted by white flies and contaminated material (IFPRI and PBS, 2007).

The Root and Tuber Improvement Programme (RTIP) was successful in introducing 60 research programmes. This resulted in five new cassava varieties with higher yields and better disease and pest resistance. It was also successful in developing Integrated Pest Management (IPM) techniques to combat Cassava Green Mite and grasshoppers. The programme again made it possible for over 120,000 farmers have access to improved varieties under an efficient three tier multiplication and distribution system across 50 districts. However, this did not translate directly into increased incomes emanating from several reasons among which was the high production cost of RTIP-introduced practices and varieties and relatively lower prices (RTIP Report, 2004)

Despite the economic importance of cassava and its numerous benefits, it is still been cultivated by the rural poor who have less access to funds to finance capital investments (farming equipment and transport) and operating expenses (production and processing). These poor farmers are also prone to risk and have lower capacity to withstand unexpected events. This has led to high reliance on labour and other traditional ways of doing things affecting their ability to minimise production cost and operate at optimal expenditure levels.

1.3 Research Questions

What are the major activities in cassava production?

What are the key inputs and cost at each activity level?

How much is spent on each activity of production?

What is the required optimal expenditure level of each activity of production

Are farmers operating at the required optimal expenditure levels?

What adjustments are required to operate at the desired optimal expenditure levels?

1.4 Objectives of Study

The main objective of this study was to identify and analyse key inputs, activities and optimal expenditure levels that will minimise farmers' total cost of production as well as cost at each major activity level of cassava production in the Transition and Forest AEZs of Ghana.

Specific Objectives

To identify the major activities, key inputs and level of expenditure of for cassava production in the Transition and Forest zones.

To estimate cost of production incurred by farmers in the study area

To find the optimal activity expenditure levels that would minimise total cost of production as well as cost at each major activity level.

1.5 Background Hypothesis

For this study, it is hypothesised that expenditure on both major and sub-activities of cassava production has positive effect on total cost of production and minimising cost at each activity level will also minimise total cost of production.

1.6 Justification of Study

This study will help cassava farmers to increase profit margins by reducing cost of production. Since profit can only be obtained or increased either through maximising returns or minimising cost, this study provides useful information for increasing profit through cost minimisation. The Ghanaian cassava farmer has no control over market prices. Prices are determined by the forces of demand and supply in which the farmer is weak. The market as well as supply from the farmer is both unstable. The only option for the farmer to increase profit is to minimise cost since this will even enable him/her sell at a lower price and increase returns as well.

Ghana as a developing country has 60% of its labour force in agriculture contributing 34.1% to GDP (MoFA-SRID, 2009). The story is however sad since about 28.5% of Ghanaians still live below the poverty line (Anonymous, 2009) with majority being farmers who live in the rural areas. For cassava farmers, the poverty situation is endemic since the crop is grown by poor Ghanaians and crucial to their food security (RTIP interim evaluation report, 2004). This is coupled with food insecurity with about 2 million people being food insecure (Anonymous, 2009). This makes one wonder what is wrong with the agricultural sector and its inability to help alleviate poverty. The answer is however clear since our agriculture is still at the primary stage even in the 21st century. There is therefore the need to investigate into ways to minimise cost of production by operating at the optimal expenditure levels in order to increase returns and help reduce poverty.

This study also serves as a response to helping farmers to be efficient in their use of resources. Minimising cost of production can free resources for other uses. Since Ghana's agriculture is basically production of raw materials to which cassava is no exception, there is the need to add value to increase returns and profitability. This can only be done when farmers have the needed resources for value addition. Since the farmer is faced with scarcity of resources, the only option is minimisation of cost to be able to save resources for other uses.

1.6 Organisation of Study

This study is organised into five Chapters. Chapter One begins with the origin and use of cassava and contribution of cassava to the economic development of Ghana. This is followed by the problem statement, research questions, objectives of study and justification. Chapter Two takes a look at relevant literature to the study; that is theoretical review involving definitions of terms and concepts and what other authors have reported concerning the topic. Empirical review of similar works is also done. Chapter Three follows and gives an indication of the study area, data collection procedure and method of analysis. Results of data analyses are presented in Chapter Four. Primary data from the field is given meaning through the use of descriptive statistics and quantitative analysis. Chapter Five summaries and draw conclusions to the study. This leads to making recommendations as to how cost minimisation can be improve in cassava production.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on production and performance, consumption and utilization and cost and profitability of cassava production in Ghana. This is followed by theoretical review of cost and cost theory, cost functions, cost equations and curves, concept of optimisation and overview on cost minimization. The chapter ends by reviewing empirical works on cost minimisation and optimisation theories.

2.2 Cassava Production and Development in Ghana

For the past decades, cassava has risen to become a key crop in Ghanaian agricultural and Africa as a whole. With farmers initially introducing cassava as a food security crop in places where it had not previously been grown, especially in dry areas and marginal lands, it has gradually become a commercial crop for most farm households. This has been due to the ability of the crop to withstand drought and survive under harsh conditions (FAO, 2000).

2.2.1 National and Regional Production Outputs among Key Staples

Cassava as a food security and commercial crop is grown and eaten in all agro-ecological zones in Ghana. In terms of administrative locations, the crop is produced in eight regions out of the ten regions in Ghana (IFPRI and PBS, 2007). The two non- producing regions are Upper East and Upper West which recorded zero hectares in 2005 (SRID-MoFA, 2006). Its production is spread across every district/metropolitan/municipal. Appendix I shows the total holders cultivating cassava across the various districts/metropolitan/municipal in Ghana.

Cassava production over the years has been very remarkable. Comparing its performance against other crops clearly puts it above all other crops in Ghana. Using data from 1997 to 2005 (MoFA, various issues), the average cropped area for cassava was 730,060 ha coming second after maize with 759,786 ha (Appendix II). However, averaging 1997-2005 production figures, cassava came first in terms of production volume with an average of 9, 219, 049MT, yam second with 3, 551, 607MT and plantain 2,255, 814MT third (Appendix III). This was not surprising since in terms of average yield per hectare cassava came second after yam over the same period. Taking an average of the average yields of the major crops from 1997 to 2005, cassava stood at 12.5MT/ha, ranking second to yam 12.8MT/ha (Appendix IV).

Analysing the performance of cassava on regional basis reveals a very interesting picture. For cropped area, Eastern Region came first with 179,963 ha, Brong Ahafo been second with 140 404ha and Ashanti 125 065ha third taking an average over the period 1997 to 2005 (Appendix V). Eastern Region confirmed its superiority in terms of production volume with an average of 2,311,199MT for the 1997 to 2005 period. Brong Ahafo was second with 2,046,245MT and Ashanti third with 1,308,988MT (Appendix VI). The story did not however favour the leading producing regions in terms of average yield per hectare over the 1997 to 2005 period. Volta region came first with an average of 16.4MT/ha and Central second with 14.0MT (Appendix VIII). Eastern, Brong Ahafo and Ashanti recorded 12.6MT/ha, 14.3MT/ha and 10.5MT/ha respectively (Appendix VIII). This might be due to several reasons in terms of varieties, technologies, soil fertility among others which need further research.

2.2.2 Consumption and Income Generation

Cassava as a food security crop is consumed by almost all households in Ghana. This is either in the form of gari, tapioca, fufu or konkonte which are local Ghanaian dishes. Cassava is very important to the food security status of the Ghanaian household such that much of household income is spent on it (Table 2.1). This explains why in 1985, cassava led in per capita consumption of starchy foods with 146.3kg as compared to 43kg for yam. This per capita consumption has increased over the years from 146.3kg in 1985 to 152.9kg in 2005 compared to yam which has decline from 43.8kg (1985) to 41.9kg (2005) as shown in Table 2. 1

Table 2.1 Estimated Levels of Per Capita Consumption of Starchy Staples (Kg)

	1985	1990	1995	2000	2005
Cassava	146.3	148	149.7	151.4	152.9
Yam	43.8	43.3	42.8	42.3	41.9
Cocoyam	NA	54	55	56.0	40.0
Plantain	82.5	83	83.5	84.0	84.8

Source: MoFA, 2009

Cassava utilisation in Ghana and its impact on income generation and employment is great. According to GSS (1995), 16 percent of cassava growing households sold US$32.2 million worth of cassava compared to US$41.4 million by 55 percent of maize growing households. In addition, the estimated total value of gari and cassava flour estimated by the GLSS I survey was US$10.7 million compared to the next highest value of US$6.1 million for processed fish. Ten thousand farming households were involved in the production of cassava chips for exports, earning an average of US$150 per household in 1996 (GSS, 1995). These values indicate a growing importance of the crop in income generation and more generally a probable shift from a subsistence crop to a cash crop (FAO, 2000)

2.3 Cost and Profitability of Cassava production

Cassava production in Ghana is a labour intensive activity involving the use of simple tools such as the hoe and cutlass. Fertilizer is applied in recent times as a means of boosting yield. Production starts with land preparation involving land clearing, stumping and ridge/mound making. Planting takes place after the land is prepared and farm maintenance in the form of fertilizer application and weeding continuous till the crop mature. The stage of activity that ensures the crop produce gets to the consumer involves harvesting (uprooting tubers from the ground), bagging, carting and transporting to market centres.

Cassava production in Ghana is very lucrative and profitable. Profitability however differs from each agro-ecological zone. Statistics from MoFA as illustrated in Appendix VI. For the 2008 crop season, farmers in the Forest and Coastal Savannah zones had net revenue for of GHC GH₵ 332.1 and GH₵ 218.2 respectively. This translated to returns to investment of 107.8% and 83.3% for the Forest and Coastal Savannah respectively (Appendix VI).

Unfortunately, MoFA did not provide statistics for the other agro-ecological zones among which include the Transition zone. Comparing how the situation look like in other zones therefore becomes impossible. Cost minimisation did not form part of this analysis. As to whether the total cost of production in any of the zones is the cost minimising level cannot be ascertain. This makes this study more relevant since it will fill in the gaps. That is providing information as to what the story looks like in the Transition zone and whether the estimated cost is the cost minimising level or not.

2.4 Theoretical Review of Cost Theory and Concepts of Optimisation

2.4.1 Overview of Cost Theory

In economics, business, retail and accounting, cost is the value of money that has been used up to produce something and hence is not available for use anymore (Anonymous, 2010). The cost of any good is the cost of goods and services derived from the technology and inputs used to produce them (Arthur, 1973).

In economics, cost is an alternative that is given up as a result of a decision. In business, cost may be one of acquisition in which case the amount of money expended to acquire it is counted as cost. In this case, money is the input that is gone in order to acquire an item. This acquisition cost may be the sum of the cost of production as incurred by the original producer and further costs of transaction as incurred by the acquirer over and above the price paid to the producer. Usually, the price also includes a mark-up for profit over the cost of production. Costs are often further described based on their timing or their applicability. That is cost is time bound and quoted with reference to a particular time. Cost at one point in time might not be the same at another point in time (Anonymous, 2010).

2.4.2 Cost Functions, Equations, Curves and Theory

The term cost function is used to denote cost expressed as a function of output and input prices. Cost equation, however, expresses cost as a function of input levels and input prices (Henderson et al, 1980). Arthur (1973) also define the cost function as a function that indicates what the cost will be at alternative output rates. This function relates output to the cost of production. Output however depends on input prices and the quantity of inputs employed. This creates a link between input prices and cost of production. Thus cost being a function of input prices and output C= f (w, y), where C= Cost of production, w=Input prices and y= output produced. This function can be represented graphically, termed the cost curve. Linking cost function and its associated properties and analysis gives the cost theory which is the theory that the price of an object or condition is determined by the sum of the cost of the resources that went into making it. The cost can compose of any of the factors of production including labour, capital, or land

2.4.2.1 Types of Cost and Cost Functions

There are various types of cost functions, curves and equations. The use of a particular type however depends on the objective of analysis. In terms of time, two main types can be identified. That is short-run and long-run cost. The short-run been cost incurred when at least one input of production is fixed and variable. Long-run cost however refers to the production stage when all inputs are variable. A graphical representation gives us the short-run and long-run cost curves.

Based on total cost, three types can be identified: Total Fixed Cost (TFC), Total Variable Cost (TVC) and Total Cost (TC) of production. TFC is the sum of cost of all the fixed inputs associated with the firms operations. TVC is the sum of the amount a firm spends on variable inputs employed in the production process (Arthur et al., 1973) and TC is the sum of fixed and variable cost for the production process.

Four types of unit cost families can be identify. These are: Average Total Cost (ATC), Average Fixed Cost (AFC), Average Variable Cost (AVC) and Marginal Cost (Arthur et al, 1973). ATC is the total cost of producing one unit of output. AFC likewise is fixed cost per unit output. Variable cost per unit of output of production is term the AVC and cost of production any additional unit of output is termed the MC.

Based on the shape of a cost curve, the curve can be linear or quadratic. There are many functional forms of cost functions such as Cobb-Douglas, transdential, Exponential and others. These functional forms are however transformed to become either linear or quadratic. Empirical studies have shown that most firms have linear functions since TC function is with constant marginal cost in pattern that best seems to describe actual cost behavior over the "normal" operating range of output (Arthur, 1973).

2.4.3 Concept of Optimisation

Optimization theory is the specific methodology, techniques, and procedures used to decide on the one specific solution in a defined set of possible alternatives that will best satisfy a selected criterion. This includes linear and nonlinear programming, stochastic programming, and control theory. It is sometimes referred to as mathematical programming in mathematics and computer science which involves choosing the best element from some set of available alternatives. In the simplest case, this means solving problems in which one seeks to minimize or maximize a real function by systematically choosing the values of real or integer variables from within an allowed set. More generally, it means finding "best available" values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domains (Anonymous, 2010).

Optimisation can be without constraint or with constraint. This depends on the situation that needs to be optimised with a bit of value judgment. The need to optimise depends on the value judgment of the analyst or employers. Firms normally wonder whether profits should be maximised or cost be minimised. The way to go round this is to bridge the gap since either ways involves opportunity cost.

Unconstrained optimisation is when the objective function itself posses a maximum or minimum and is subject to no restrictions over the range of variation in its value (Henderson and Quant, 1980). This is done by finding the first order conditions of optimisation (necessary conditions) and the second order conditions for optimisation (sufficient conditions).

Constraint optimisation however is maximising or minimising an objective function by imposing some restriction or constraints (Henderson and Quant, 1980). This constraint can either be equality constraint or inequality constraints. To solve optimal inequality-constrained problems, a system of inequalities called the 'Karush-Kuhn-Tucker conditions' or 'complementary slackness conditions', which may then be used to calculate the optimum need to be calculated. That is, forming the Lagrange equation and finding the first and second order conditions of optimization. While the first derivative test identifies points that might be optimal, it cannot distinguish a point which is a minimum from one that is a maximum or one that is neither. When the objective function is twice differentiable, these cases can be distinguished by checking the second derivative or the matrix of second derivatives (called the Hessian matrix) in unconstrained problems, or a matrix of second derivatives of the objective function and the constraints called the Bordered Hessian (Anonymous, 2010)

2.4. 4 Overview and Definition of Cost Minimisation

Cost minimisation is the process of choosing a combination of inputs to produce a certain level of output at minimum cost. In other words, it is the process or goal of incurring the least possible opportunity cost in the pursuit of a given activity (Economic glossary, 2010). This involves the behavioural assumption that an individual or firm will seek to purchase a given amount of goods or inputs at the least cost, other things being equal. By making certain assumptions, there will exist a single cost-minimising combination of inputs for any level of output (http://www.encyclopedia.com). Minimisation of some objective can be termed minimisation of a function involving economic variables. This function is term the objective function (Henderson and Quant, 1980).

Cost minimisation is achieved through optimisation theory. That is, finding the necessary and sufficient conditions of optimisation which ensure the least cost of producing a certain output. The necessary conditions can be attained by finding the first order conditions and the sufficient condition by differentiating twice the objective function with respect to each variable of interest. The approach to finding the minimum cost that will help achieve maximum output will depend whether the problem is subject to a constraint or not. For a constraint function, the approach is modified by the use of the Lagrange multiplier where a Lagrange equation is formed with the integration of the objective function and the constraint.

The levels of inputs that ensure a cost minimisation level is known as input conditional demand function or equations. These input demand functions are derived by solving the first order conditions of the optimisation problem. This is done simultaneously depending on the number of variables involved. Where the variable or inputs are more than one, matrices involving the use of Hessian determinants or Boarded Hessian is used to find these input demand equations.

2.5 Empirical review on cost minimisation and optimisation theory

Allen et al; (1995) conducted a study on farm-level nonparametric analysis of cost-minimisation and profit –maximisation behaviour .This study was conducted in the United States where two hundred and eight nine Kansas farms were studied. Data on eight inputs obtained from the Kansas Farm Management Association record from 1973 to 1990 was analysed under cost-minimisation and profit maximisation hypotheses using deterministic and stochastic test. They find out that under deterministic test, none of the farms were either cost minimising or profit maximising. Under the stochastic test, all two hundred and eight nine farms failed the profit maximisation hypothesis while 171 farms failed cost minimisation hypothesis. Allowing for non-regressive technical change did not change the result much. Two hundred and seventy six farms violated the profit maximisation hypothesis and 138 farms violated the cost minimisation hypothesis.

One major shortcoming of this study is that it concentrated on farms and not individual farmers. Allen et al;(1995) made it clear the limitations of previous works on optimisation behaviour was the use of national or state-level data. This to them did introduce aggregation bias since individual agents face different technology and have different objectives and again producers face varying market conditions. As a way of improving upon the limitation they identified, they choose to use farm level data of well organised farming companies in the form of farm records. This is still a form of aggregation compared with individual small scale farmers. These farms are cooperate bodies who access inputs and market their products in a more organised manner. In this light, challenges in terms of input cost and revenue generated will be different if viewed from the small scale farmer point. That is why this study is concentrating on individual small scale farmers who produce the bulk of cassava in Ghana as compared to well organised farming companies.

Another limitation of Allen et al; (1995) study was that, they did not make clear as to how much each farm was spending on inputs or revenue from sales that minimised or maximised cost and profit respectively. The interest was done was to determine whether the farms were cost minimisers or profit maximisers based on their ability to pass a deterministic or stochastic test. It is not enough to just determine the minimisation or maximisation status of a farm or farmers without establishing the point at which optimisation status is achieved. This is one of the things that this study seeks to address.

Briggs et al; (2001), conducted a study on “the death of cost –minimization analysis”. That is they demonstrated the four main forms of economic evaluation methods namely; Cost Benefit Analysis (CBA), Cost Utility Analysis (CUA), Cost Effective Analysis (CEA) and Cost –Minimisation Analysis (CMA). They stated that among the four evaluation methods, CMA has considerable appeal to analysts who want to keep to studies and evidence simple (Briggs et al, 2001).

They explained the circumstance under which CMA could be used. Donaldson et al., (1996) stated that in designing prospective economic evaluation, it was not possible to specify the technique of analysis (CEA versus CMA) because the data are unknown, Briggs et al.,(2001) however stated even when data are known, CMA is rarely appropriate as a method of analysis. CMA to them is most appropriate when a randomized trial has been designed to test the explicit hypothesis of equivalence in outcome between two therapies.

The limitation of Briggs et al., (2001) study just like other studies focused on alternative treatments. That is when to apply CEA or CMA when analysing alternative treatments. They did not analysis as to when it is appropriate to apply any of these methods and when dealing with individual treatment cost minimisation problem and how much should be spent to achieve minimum cost.

Ojeda et al., (2003) studied "cost-minimisation analysis of pegylated liposomal doxorubicin (PLD) hydrochloride versus topotecan in the treatment of patients with recurrent epitherlial ovarian cancer in Spain". Their objective was to compare the cost of two treatment options to establish which one was cost minimising. PLD which was one of the treatment options was chosen to be the cost minimising treatment option since it had the least cost of administration. This was achieved by identifying the resources used in administrating each of the treatments. The main categories of cost identified were; the cost of drug, cost of administration and cost of managing adverse events. The limitation of this study was the methodology used. The fact that an option has the least cost does not make it cost minimising. It is only a necessary condition and not a sufficient condition. The sufficient condition of optimisation must be fulfilled before the option can be conveniently term cost minimizing. The sufficient condition is achieved when the second order conditions for minimisation which requires the principal minors of the Hessian determinants to be positive definite is satisfied.

CHAPTER THREE

METHODOLOGY

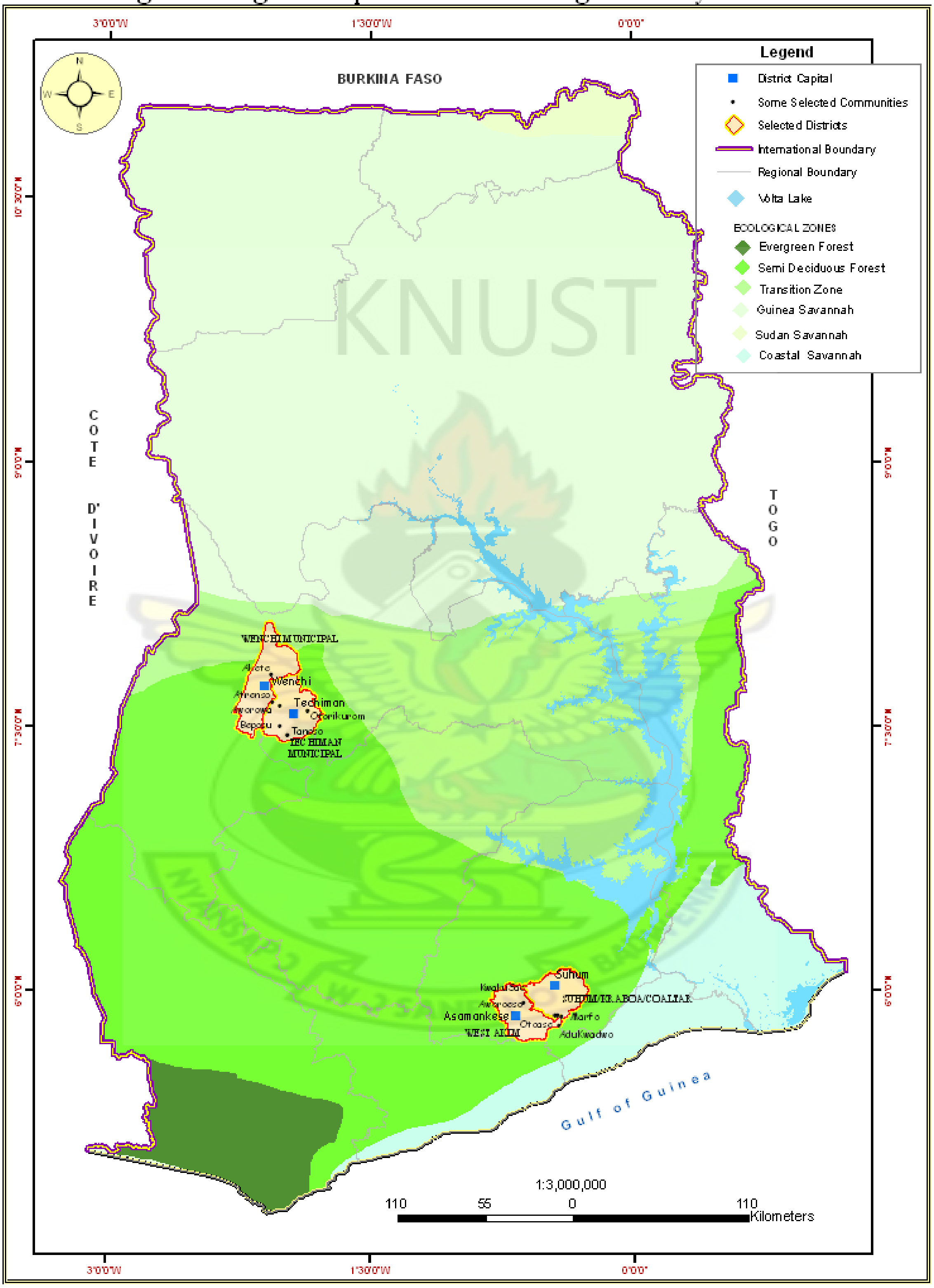
3.0 Introduction

This chapter gives a description of the study areas in terms of profile. The theory behind the study which is the classical optimisation theory is explained. Methods used in generating primary data from the study areas are discussed and this is followed by analytical tools used in achieving the set objectives.

3.1 Profile of Study Areas

This study was carried out in two agro-ecological zones of Ghana namely; Transition and Forest zones. It covered the two leading cassava production regions in Ghana (i.e Eastern Region and Brong Ahafo Region). Techiman and Wenchi Municipals were chosen for the Brong Ahafo Region as well as Suhum /Kraboa/Coaltar and West Akim Municipals for the Eastern region were considered for the study.

Agro-Ecological Map of Ghana showing the Study Area



3.1.1 Suhum/ Kraboa/Coaltar

The Suhum Kraboa Coaltar District is located in the southern part of the Eastern Region. It shares boundaries with the West Akim Municipal to the west, the Akwapim North and New Juaben Municipal to the east, the Akwapim South District to the south and the East Akim Municipal to the north. Agriculture is the bedrock of the district economy and employs about 70% of the working population. Cocoa, oil palm, cassava and plantain are the major cash crops cultivated, while poultry is also picking up in the district. Major towns in the district include; Anum Apapam, Nankese, Amanase Asuboi, Teacher Mante, Coaltar, Dokrokyewa, Akorabo, Otoase, Kofi pare, Kuano, Akyeansa, Brong Densuso, Kwaboanta, Obuoho ,Okorase, Abenabu No. 2, Sowatey and Krabokese (www.ghanadistricts.com, 2010).

3.1.2 West Akim Municipal

The West Akim Municipal with Asamankese as the capital and population of 154,161 (2000, census) growing at 2.5% is located in the Eastern Region. It has an area of about 1,018 square kilometers and shares boundaries with Kwaebibrem district to the north, Birim South to the west, Agona, Ewutu Municipal and Ga East Municipal to the south, and Suhum-Kraboa-Coalter and Akwapim South districts to the east. Agriculture is the main economic activity in the district and employs about 52.1% of the labour force with trade/commerce employing 25.3%, tradesmen/Artisans 12.0%, public servants 7.5% and the unemployed 3.0%. Main crops cultivated include cassava, plantain, cocoyam and yam (www.ghanadistricts.com, 2010)

3.1.3 Techiman Municipal

Techiman Municipal is located in the Brong-Ahafo region. Population of the Municipality stood at 174,600 with an average growth rate of 3.0% per annum and population density of over 260 persons/km^2 (GSS, 2000). Agriculture and related trade is the main economic activity in the municipality employing 57.1% of the population. The major crops grown are food crops such as yams, maize, cassava, cocoyam, plantain and vegetables like tomatoes, garden eggs, onions and okro as well as cash crops like cocoa, cashew, mango, among.

3.1.4 Wenchi Municipal

Wenchi municipal is located in the Brong-Ahafo Region of Ghana between latitudes 7°27N and 8°30N and longitudes 1°30N and 2°36W. The Black Volta marks the Northern border of the municipality, forming the boundary between the municipality and Northern region. It is bounded on the south by the Sunyani Municipality and on the west by the Tain district. The south eastern and the eastern portions form boundaries with Techiman and Kintampo Municipalities respectively. The Wenchi Municipality occupies an area of 7,619.7 square kilometres and a population density of 5-20 persons per square kilometre. It is estimated that 75% of the population are farmers growing maily cassava, cocoyam, maize, tomatoes and yam. According to the 2001 population and housing census, the population of the Municipality is approximately 169,412 with 85,439 being males and 83,973 being females.

3.2 Population, Sample and Sampling Methods

Population for this study was all cassava farmers in the transition and forest agro-ecological zones of Ghana. Due to time and resource constraint, the multi-stage sampling technique was used to select a total of four hundred (400) cassava farmers from the study areas. The first stage was purposively selecting the two Regions. This was on the basis that, these regions are the leading cassava growing regions in Ghana (MoFA, 2008). Two (2) districts were then purposively selected within a region. This was followed by the selection of ten (10) communities within a District. This led to the final stage of randomly selecting ten (10) farmers within a community.

3.2.3 Unit of Analysis

The unit of analysis for this study was cassava farmers irrespective of acreage. Information elicited from respondents included activities involved in the production process, quantities of inputs and cost, output levels, perception on cost comparative to other crops among others. This was on per acre basis.

3.3 Analytical Framework

3.3.1 Conceptual Framework

This study was based on the theory of optimisation. That is, classical optimisation theory was used in determining the extremum of the dependent variables as well as the optimal values of the choice variables.

According to Chiang and Wainwright (2005) with n-choice variables, the objective function may be express as;

$$z = f\left(x_1, x_2 ......x_n\right)................................ (1)$$

The total differential will then be;

$$dz = f_1 dx_1 + f_2 dx_2 + ...f_n dx_n .... (2)$$

The extreme value of Z is determined by finding the necessary conditions for extremum (dz =0 for arbitrary dx_i, not all to be zero) such that all the *n* first-order partial derivatives are required to be zero.

The second order differential d^2z will be an *n* x *n* array. The coefficients of that array properly arranged will give the Hessian matrix determinant

$$|H| = \begin{vmatrix} f_{11} & f_{12} \cdots & f_{1n} \\ f_{21} & f_{22} \cdots & f_{2n} \\ \cdots & \cdots & \cdots \\ f_{n1} & f_{n2} \cdots & f_{nn} \end{vmatrix}$$

Z is a maximum when all the principal minors duly alternate in sign with the first one being negative (Negative definite) such that $f_1, f_2 \ldots f_n = 0$ and $|H_1|<0$; $|H_2|>0$; $\ldots(-1)^n|H|>0$; and a minimum when the principal minors are positive definite such that $f_1, f_2 \ldots f_n = 0$ and $|H_1|>0$; $|H_2|>0$; $\ldots, |H_n|>0$ Chiang and Wainwright (2005).

3.3.2 Mathematical and Econometric Specification of Empirical Models

An empirical activity total cost model was specified such that total activity cost of production/acre depended on how much was spent on each major activity of production. Total cost was thus the dependent variable and expenditure on major activities of production as the explanatory variables. These explanatory variables also depended on other variables. Separate models were thus specified and estimated (Table 3.3.2).

Table 3.3.2: Empirical Models Specifications and a-prior Expectations

Total Cost of Cassava Production Dependent: TCCP/acre		Total Cost of Land Preparation Dependent: TCLP/acre		Total Cost of Planting Dependent: TCP/acre		Total Cost of Farm maintenance Dependent: TCFM/acre		Total Cost of Harvesting and Post-harvest Dependent: TCH/acre	
a-priori Expectations	Variable	a-priori Expectations	Variable	a-priori Expectations	Variable	a-priori Expectations	Variable	a-priori Expectations	Variable
$\beta_1 > 0$	TCFM	$\alpha_1 > 0$	CLP_1	$\gamma_1 > 0$	CP_1	$\varepsilon_1 > 0$	CFM_1	$\mu_1 > 0$	CH_1
$\beta_2 > 0$	TCLP	$\alpha_2 > 0$	CLP_2	$\gamma_2 > 0$	CP_2	$\varepsilon_2 > 0$	CFM_2	$\mu_2 > 0$	CH_2
$\beta_3 > 0$	TCP	$\alpha_3 > 0$	CLP_3	$\gamma_3 > 0$	CP_3	$\varepsilon_3 > 0$	CFM_3	$\mu_3 > 0$	CH_3
$\beta_4 > 0$	TCH			$\gamma_4 > 0$	CP_4			$\mu_4 > 0$	CH_4
Error Term	μ_t		μ_{lp}		μ_p		μ_m		μ_h

1. TCCP=Total cost of cassava production, TCFM=Total cost of farm maintenance, TCLP=Total cost of land preparation, TCP=Total cost of planting, TCH=Total cost of harvesting,
β_{0-4}=Parameters to be estimated, μ_t =error term

2. TCLP=Total cost of land preparation, CLP_1= Cost of land clearing, CLP_2 = Cost of stumping, CLP_3= Cost of ridging, α_{0-3} = parameters to be estimated , μ_{lp} =error term

3. TCP=Total cost of planting, CP1=cost of stem cuttings, CP_2=Cost of transporting stem cuttings, CP_3=Cost of labour for planting stem cuttings, CP_4=cost of labour for sorting stem cuttings, γ_{0-4} = parameters to be estimated , μ_p =error term

4. TCFM=Total cost of farm maintenance, CFM_1=cost of weeding, CFM_2=Cost of fertilizer, CFM_3=Cost of labour for fertilizer application, ε_{0-3} =parameters to be estimated, μ_m =error term

5. TCH=Total cost of harvesting, CH_1=Cost of labour for harvesting roots, CH_2=Cost of labour for carting produce, CH_3=Cost of bagging, CH_4=Cost of transporting produce, μ_h =error term

Procedure for Parameter Estimation of Empirical Models

The ordinary least square (OLS) estimator was used in estimating the parameters for the various models. This was because OLS is the best linear unbiased estimator (BLUE). The basis for using this estimator is because empirical studies on cost functions have shown that most firms have linear functions since TC function is with constant marginal cost in pattern that best seems to describe actual cost behavior over the "normal" operating range of output. This was proved by studies done by Lester (1946), Hall and Hitch (1939), Johnson (1941), Dean (1976, 1941), Ezekieal and Wylie (1941) cited in Arthur et al; (1973).

3.4 Hypotheses

Two hypotheses were tested using the F-test in investigating the effect of the explanatory variables on total cost of cassava production (TCCP) as well as cost of major activities.

For expenditure on TCCP, it was hypothesized that;

H_0: Expenditure on major activities of production has no effect on total cost of production

H_1: Expenditure on major activities of production has a positive effect on total cost of production

For expenditure on sub-activities on major activities, it was hypothesised that;

H_0: Expenditure on sub-activities of production has no effect on cost of that activity.

H_1: Expenditure on sub-activities of production has a positive effect cost of that activity.

3.5 Analysis of Specific Objectives

Descriptive statistics such as means, bar graph, pie chart and frequency tables were used to achieve objective one which has to do with identifying the major activities of the production process, key inputs and level of expenditure. Objective two and three were achieved using the regression analysis as well as the classical optimisation theory. The Hessian determinant matrix as well as Laplace expansion was employed in finding the sign of definiteness of the second order derivatives in search for the extreme value of the dependent variables.

Policy or Control Usefulness of Empirical Models

Upon having an idea of the minimum production cost, policy makers will have an idea as to whether farmers' current practices are capable of meeting the minimum cost level. This will help in formulating policies that will ensure cost of inputs are low in ensuring farmers and other investors meet the minimum cost level to help increase profit margins.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides results from empirical survey conducted and analysis of the socio-demographic characteristics of the respondents. This is followed by analysis on the nature of production, key inputs, cost structure and cost minimisation at major activity levels as well as sub-activity levels. Finally, cost and profitability analysis was carried out to confirm cost minimisation situation of the farmers in the study area.

4.2 Socio-Demographic Analysis

From Table 4.2.1, about 71.8% of respondents in the study area were males. This was due to the labour intensive nature of operations involved in cassava production which did not favour. females. The labour intensive nature of cassava production is confirmed by Table 4.2.2 with a mean age of 45 years which falls within the youthful age bracket. Age was skewed towards old age with a maximum age of 80 years. This means the youth are not entering into this industry and mean age might have resulted from a youthful generation a decade ago.

Most of the farmers in the study areas interviewed were educated. About 77% had basic education comprising of 10 years of middle school or 9 years junior high school education. However, some of the respondents did not complete either of these systems of basic education. This is why the average years spent in school was 8 years (Table 4.2.2)

Farming was the main occupation with 93.1% engaged in farming and cultivating cassava. The remaining 7.9% did farming as a secondary occupation. Others were students, artisans, traders and civil servants. These groups were spending less time in their farms as compared to those engaged in farming as primary occupation (Table 4.2.1).

About 79.4% of respondents were natives with 20.6% being migrants (Table 4.2.1). This made land availability not to be a problem for farming in the study area. Most farmers were operating on family lands or on their own land which they had purchased or inherited. The migrant did also acquire land in the form of sharecropping or rental basis which was not much prevalent since most of them were natives as stated earlier.

Table 4.2. 1: Summary of socio-demographics

Gender		**Education level**		**Main Occupation**		**Residential status**		**Age structure**	
Variable	*Freq*	*Variable*	*Freq*	*Variable*	*Freq*	*Variable*	*Freq*	*Variable*	*Freq*
Male	71.8	Basic	77.0	Farmers	93.1	Native	79.4	21-40	37.1
Female	28.2	Secondary	5.8	Traders	2.4	Migrant	20.6	41-60	54.7
		Tertiary	0.8	Civil servants	0.5			Above 60	8.3
		No Education	15.8	Students	1.1				
		Other	0.5	Artisans	0.8				
				Farmer and Trader	2.1				

Source: Field survey, 2010

Socio-demographic characteristics of the two agro-ecological zones had some similarities and differences. Both zones had more males than female (Table 4.2.2). The Forest zone however had more males than the Transition zone who provided the needed household labour and explains why labour accessibility was not a problem in the forest zone with 67.9% having readily access to labour (Table 4.2.5).

In terms of access to land, farmers in the Transition zone had more access than their colleagues in the forest zone. Accessibility by virtue that farmers were natives in the Transition zone was 80.2% compared with 78.6% (Table 4.2.2). This means that generally land was not a problem since most farmers were natives.

Table 4.2.2: Comparing Socio-Demographics for the Forest and Transition zones

Variable	Forest Agro-Ecological Zone	Transition Agro-Ecological Zone
	% Frequency	
Gender		
Male	76.5	67.4
Female	23.5	32.6
Education level		
Basic	82.6	71.5
Secondary	7.1	4.7
Tertiary	0.0	1.6
No education	9.2	22.3
Other	1.1	
Main occupation		
Farmers	95.7	90.7
Traders	1.1	3.6
Civil servants		1.0
Students		2.1
Artisans		1.6
Farmers and traders	3.2	1.0
Residential Status		
Native	78.6	80.2
Migrants	21.4	19.8
Age distribution		
21-40	34.4	39.7
41-60	58.1	51.3
Above 60	7.5	9.0

Source: Filed Survey, 2010

Table 4.2.3: Summary of Quantitative Variable

Variable	Minimum	Maximum	Mean	Std. Deviation
Age distribution of farmers	21	80	45	11.196
Number of years farmers spent in school	0	18	8	4.018
Cassava output per acre (Mt)	0.1	54.6	5.8	14.31030
Total acreage for cassava cultivation(acres)	1	15	3	1.652
Selling price of cassava/maxi bag(GH₵)	7	100	33.58	19.139
Number of years in farming	1	60	19	11.151
Number of years in cassava cultivation	1	60	18	11.186
Number of extension contact with farmers in 2009 crop season	0	120	10	15.497
Amount of capital invested in 2009 crop season	30	3000	326.09	341.465

Source: Field survey, 2010 Note $1= GH₵ 1.40

From Table 4.2.2, the average productivity of the farmer is 5.8Mt/acre (14.5Mt/ha) compared to the national average of 13.8Mt/ha (MoFA, 2009). This was as a result of farmers spending on the average 8years in school. This was mostly through the middle school system or junior high school system. Farmers had 18 years experience in cassava farming and 10 extension contacts for the crop season (Table 4.2.2)

Table 4.2.4: Comparing Quantitative Variables for the Forest and Transition zones

Variable	**FOREST ZONE**	**TRANSITION ZONE**
	Mean	Mean
Age distribution of farmers	46	45
Number of years farmers spent in school	9	7
Cassava out per acre (maxi bags)	27	15
Total acreage for cassava cultivation(acres)	2	3
Selling price of cassava/maxi bag(GHC)	23.65	41.87
Number of years in farming	19	19
Number of years in cassava cultivation	19	17
Number of extension contact/year	13	7
Amount of capital invested in 2009 crop season	343.10	273.12

Source: Field survey, 2010

Table 4.2.5: Summary of Dichotomous Variables

Variable	**FOREST ZONE**		**TRANSITION ZONE**	
	Yes	No	Yes	No
FBO Membership	35.9	64.1	17.6	82.4
Access to funds from financial institutions	2.1	97.9	17.9	82.1
Access to funds from family relatives	6.4	93.6	4.7	95.3
Self financing	96.3	3.7	92.8	7.2
Interest on self financing funds	100	0.0	0.0	100
Labour availability	67.9	32.1	49.4	50.6

Source: Field survey 2010

4.3 Production Activities, Key Inputs and Ecological Effect

4.3.1 Production Activities and Key Inputs

Cassava production is a labour intensive activity which spans from land preparation to transporting produce to the market. This is why farmers ranked labour as the most key input applied at various levels of the production process (Table 4.3.1). This is confirmed by Awoyemi (2006) who indicated labour was the most limiting factor I cassava production.

The production process can be divided into four main activity levels namely; land preparation, planting, farm maintenance and harvesting and post-harvest activities. Each activity also comprises sub- activities which involves the use of different inputs (Table 4.3.1). Labour and cutlass are the key inputs under land preparation. Labour again takes care of planting activities as the most key input. For farm maintenance, fertilizer coupled with labour were the key inputs and finally vehicle for transportation and labour for bagging produce were chosen as the key inputs for harvesting and post harvest activities.

It is worth to note that not every farmer undertake every activity involve in the production process (Table 4.3.1). Certain activities depend on the nature of land. Others depend on farmers' practice and technology. Stumping for example is normally carried out on fresh lands where trees and stumps need to be removed. Fertilizer application is farmer specific. Farmers who desire higher yield apply fertilizer (33.4%) to boost soil fertility. This explains why some activities are not undertaken by every farmer (Table 4.3.1).

Technology applied can be broadly group into two. That is traditional and mechanised technology. The traditional has to do with the use of manpower as compared to mechanised technology which as to do with use of agro-chemicals and machines. Some activities involve the use of both traditional and modern. Land clearing, weeding and transporting produce involves either traditional or mechanised technology. Land is cleared using tractor or manpower involving the use of the cutlass. Weeding is also done manually or through the use of weedicide. Transporting produce to market centres is done by head portage or the use of vehicles. Other activities such as stumping, ridging/mounding, sorting among others involved the use of only traditional technology. These activities are yet to be mechanised.

Table 4.3.1: Summary of Production Activities and Key Inputs

Activity	**% of farmers who undertake activity**	**Use of traditional technology (%)**	**Key input**	
			Input	% Freq
Land preparation				
Land clearing	100	97.9	Cutlass	48.1
Stumping	57.1	57.4	Cutlass	20.7
Ridging	50.3	50.3	Labour	35.5%
Planting Activities				
Sorting of stem cuttings	87.4	87.4	Labour	51.0
Actual planting of cuttings	100.0	100	Labour	43.8
Farm maintenance				
Weeding	100	96.3	Cutlass	55
Fertilizer application	33.4	100	Fertilizer	33
Harvesting and post-harvest Activities				
Harvesting of roots	100.0	100.	Labour	43.1
Bagging	57.9	57.9	Labour	31.7
Transporting	78.4	58.2	Vehicle	52.1

Source: Field survey, 2010

4.3.2 Effect of Agro-Ecological zone on Production Activity

To be able to establish and explain difference in production activities in the two zones, a Chi-Square test of hypothesis was conducted. This was to test the dependence of production activities on ecological zone. The null and alternate hypotheses were stated as;

H_O= Production Activities do not depend on Agro-ecological zone

H_1= Production Activities depend on Agro-ecological zone

Results from Table 4.3.2 indicate that the Pearson Chi-Square values for stumping, ridging/mounding, fertilizer application, bagging and transporting produce were highly significant at 1% level. This means the null hypothesis is not accepted in faviour of the alternate hypothesis. In order words, the test show that farmers will undertake a particular production activity depending on the agro-ecological zone they find themselves. The number of farmers undertaken a particular activity in the Transition zone will therefore differ from the Forest zone. Other activities such as land clearing, planting, weeding and harvesting were constant. Every farmer undertook these activities irrespective of agro-ecological zone.

Table 4.3.2: Pearson Chi-Square test of dependence between Agro-Ecological zone and Activities

Activity	Pearson Chi-Square Value	Asymp. Sig. (2-sided)
Land preparation		
Land clearing	Constant	Constant
Stumping	1.457E2[a]	0.000
Ridging/mounding	92.928[a]	0.000
Planting Activities		
Sorting of stem cuttings	40.569[a]	0.000
Actual planting of cuttings	Constant	Constant
Farm maintenance		
Weeding	Constant	Constant
Fertilizer application	1.406E2[a]	0.000
Harvesting and post-harvest Activities		
Harvesting of roots	Constant	Constant
Bagging	1.294E2[a]	0.000
Transporting	11.093[a]	0.001

Source: Field Survey, 2010

In terms of activities undertaken by farmers in the production process, there were some differences when the results of the two zones were compared. About 88.2% of respondents interviewed in the forest zone undertook stumping in contrast to 26.9% in the transition zone. This was due to the nature of vegetation since the forest zone comprise of trees while the transition has less trees and more grass lands. Sorting stem cuttings before planting was much practiced in the forest with 98.4% compared with 76.7% for the transition zone. Fertilizer application was also a common practice in the Forest zone with 62.5% of farmers applying fertilizer. The story in the transition was however different with only 5.2% applying fertilizer (Table 4.3.3)

The reason accounting for the difference in some practices among the two zones (e.g. stem cuttings sorting and fertilizer application) can be attributed to the number of extension contacts and Farmer Based Organisation (FBO) membership. Farmers in the forest had an average of thirteen (13) extension contacts/year compared with seven (7) extension contacts/year for the transition zone. More farmers in the forest zone did belong to FBOs than those in the transition zone (Table 4.2.5).

The cutlass was rated the key input for production in the Forest zone. Out of nine activities, cutlass emerged as the key input for five of them with labour appearing in two activities. (Table 4.3.3). This was because 67.9% of cassava farmers in the Forest zone had easy access to labour in the form of household labour. They therefore deem it necessary in getting an input to complement labour and thus choose cutlass as a key input.

With less availability of labour (49.4%), farmers in the Transition zone choose labour as they most key input in production (Table 4.2.4). Out of the nine activities ranked, labour did appear as key input in seven of them (Table 4.3.3).

Table 4.3.3: Comparing summary of key production activities and key inputs in the forest and transition zones

Activity	FOREST ZONE				TRANSITION ZONE			
	% of farmers who undertake activity	Use of traditional technology (%)	Key input: Input	Key input: % Freq	% of farmers who undertake activity	Use of traditional technology (%)	Key input: Input	Key input: % Freq
Land preparation								
Land clearing	100	97.9	Cutlass	76.5	100	99	Labour	67.4
Stumping	88.2	88.2	Cutlass	46.5	26.9	27.5	Labour	24.9
Ridging	58.8	58.8	Labour		99	99.5	Labour	77.2
Planting Activities								
Sorting of stem cuttings	98.4	98.4	Labour	64.2	76.7	76.7	Labour	61.1
Actual planting of cuttings	100	100	Cutlass	70.1	100	100	Labour	68.9
Farm maintenance								
Weeding	100	100	Cutlass	72.2	100	100	Cutlass	49.7
Fertilizer application	62.6	62.6	Fertilizer	62.6	5.2	5.2	Fertilizer	5.2
Harvesting Activities								
Harvesting of roots	100	87.2	Cutlass	62.0	100	94.8	Labour	66.8
Bagging	87.2	87.2	Labour	55.6	29.5	29.5	Labour	15
Transporting	85.6	14.4	Vehicle	62.6	71.5	28.5	Vechicle	

Source: Field survey, 2010

4.4 Cost Structure of the Production Process

The cost structure of cassava production can be view in terms of activities. This clearly gives an indication as to how much the farmer spends on each activity. This is further broken down into sub- activities to help identify the specific expenditures that give the major activity expenditures.

In analysing the cost structure of cassava production in terms of activities, four major activities were identified namely; land preparation, planting, farm maintenance and harvesting (Table 4.4.1). Each activity comprise of sub- activities as shown by Figures 4.1, 4.2, 4.3 and 4.4.

Table 4.4.1 shows that harvesting and post-harvest activities take a greater percentage (27.75%) of total cost of cassava production. This is due to the difficult nature of uprooting roots from the ground, especially during dry season. This is coupled with high transportation cost which all form part of harvesting and post-harvest activities cost. Land preparation which is another labour intensive activity is followed as the next most expensive activity with GHC 101.49, representing 25.24% of total cost. This clearly shows that cassava production is still not mechanised and the use of labour very key (Table 4.4.1).

Expenditure on fixed assets (hoes, cutlasses, baskets and sacks) was low at GHC 43.29, representing 10.77% of total cost. This indicates that farmers spend less on capital investments and re-emphasises the lack of mechanisation in this industry. This affects the efficiency of the farmer and his/her ability to perform possibly well than the current state. The need for capital investment in fixed asserts will be paramount since this will increase efficiency.

Table 4.4.1: Total Cost Structure of Cassava Production/acre for the Forest and Transition zones

Activity	**Cost**	**%Share of TC**
Land preparation	101.49	25.24
Planting	69.44	17.27
Farm maintenance	76.29	18.97
Harvesting and post-harvest	111.57	27.75
Total Activity cost	**358.79**	**89.23**
Fixed cost	43.29	10.77
Total cost	**402.08**	**100**

Source: Field survey, 2010

The transition zone has a higher production cost compared with the forest zone. Total cost of production in the Transition zone was GHC 431.94, compared with GHC 362.65 in the Forest zone (Table 4.4.2). Several factors can be attributed to this disparity. Labour which is a key input in the production process was scarce in the transition zone. Only 49.6% of farmers in the transition had easy access to labour. This explains why cost was high in the transition since this situation reflected in all the labour intensive activities.

Table 4.4.2: Comparing Total Cost Structure of Cassava Production/Acre in the Forest and Transition zones

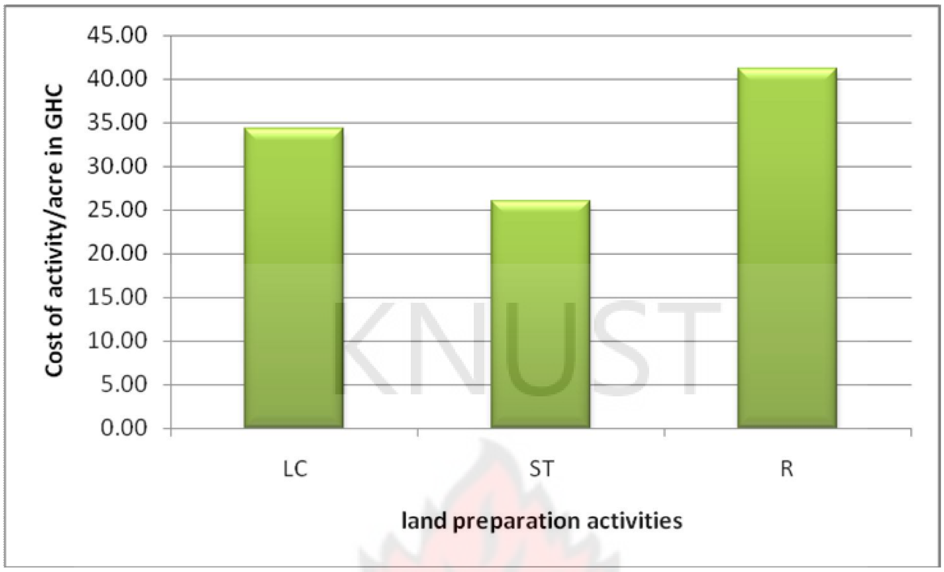
	FOREST ZONE		TRANSITION ZONE	
Activity	Cost	% share of Total Cost	Cost	% share of Total Cost
Land preparation	92.79	25.59	113.62	26.31
Planting	58.25	16.06	69.83	16.17
Farm maintenance	75.40	20.79	77.33	17.90
Harvesting	93.19	25.70	127.61	29.54
Total Activity cost	**319.62**	**88.13**	**388.40**	**89.92**
Fixed cost	43.03	11.87	43.54	10.08
Total cost	**362.65**	**100.00**	**431.94**	**100.00**

Source: Field survey, 2010

4.4.1 Land Preparation

Ridging/mounding was the most expensive activity under land preparation as shown in Figure 4.1. This was because of the labour intensive nature of this activity. Farmers spend GHC 41.22/acre out of total land preparation expenditure of GHC101.49 on ridging/mounding. The next highest expenditure was on land clearing costing GHC 34.2/acre higher than GHC 32/acre for the forest zone in 2008 (MoFA, 2008). Stumping was the least expensive item because not every farmer removes stumps depending on the nature of the land and the charge is relatively low as compared to the other activities. This is mostly done by household labour but was cost for the purpose of analysis.

Fig 4.1: Land preparation activities cost structure



LC=Cost of land clearing ST=Cost of stumping R=Cost of ridging

Cost of land preparation was higher in the transition zone than the Forest zone. With the exception of stumping, cost for all activities under land preparation in the Transition zone was higher than the Forest zone (Table 4.4.3). This was due to the fact that more people (88.2%) did stump in the forest zone as compared with the transition zone (27.5%). This is due to the nature of the vegetation since the Forest zone has a lot of trees compared with the Transition zone.

Table 4.4.3: Comparing Cost of Land Preparation/Acre in the Forest and Transition zones

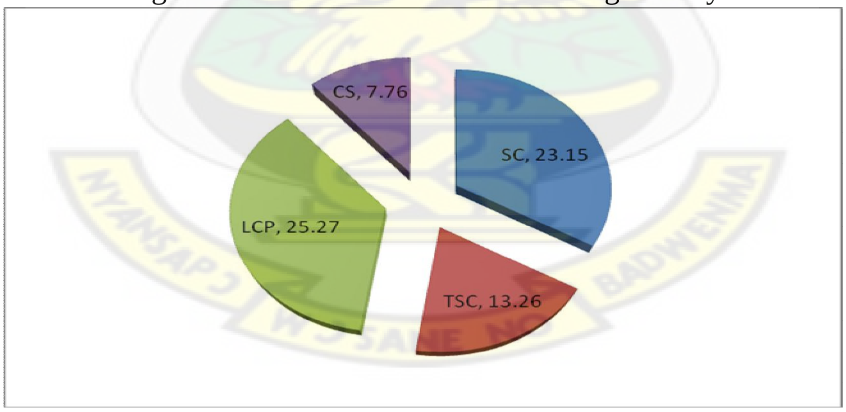
	FOREST ZONE		TRANSITION ZONE	
Activity	Cost(GH)	% share of CLP	Cost(GH)	% share of CLP
Land clearing	31.32	33.75	37.92	33.38
Stumping	26.15	28.18	25.67	22.60
Ridging/mounding	35.33	38.07	50.03	44.03
Cost of land preparation	**92.79**	**100.00**	**113.62**	**100.00**

Source: Field survey, 2010

4.4.2 Planting Activities

Labour for planting stem cuttings was the most expensive expenditure item under planting activity with farmers spending GHC 25.27/acre (Fig 4.2). This explains the significant role labour plays in cassava production. This industry is yet to be mechanised which will help reduce labour cost.

Figure 4.2 : Cost Structure for Planting activity



Source: Field survey, 2010.

LCP=Cost of labour for planting cuttings CS= Cost of sorting cuttings SC=Cost of cuttings

TSC=Transportation cost of cuttings

From Figure 4. 2, cost of stem cuttings as planting material for cassava was the next most expensive item under planting activities costing GHC 23.15/acre. This was due to the scarcity of clean planting materials which is an antidote to cassava mosaic. The only way to treat cassava mosaic is through prevention by growing resistant varieties. This has made the search for resistant varieties expensive.

The stem cuttings is usually sorted out to get good planting materials and then transported to the planting field. These activities do not cost much since it is mostly done by household labour. This explains why the cost for sorting was GHC 7.76/acre been the least cost item under planting activity and 13.26/acre for transporting stem cutting to the planting field.

There was not much difference in cost of planting activities in the two zones. Labour cost for actual planting of stem cuttings was the most expensive activity for both zones. However, in terms of total cost of planting, the transition zone was more expensive than the forest zone (Table 4.4.4) with the underlying factor been labour availability (Table 4.2.4).

Table 4.4.4: Comparing cost of planting activities/acre in the forest and transition zones

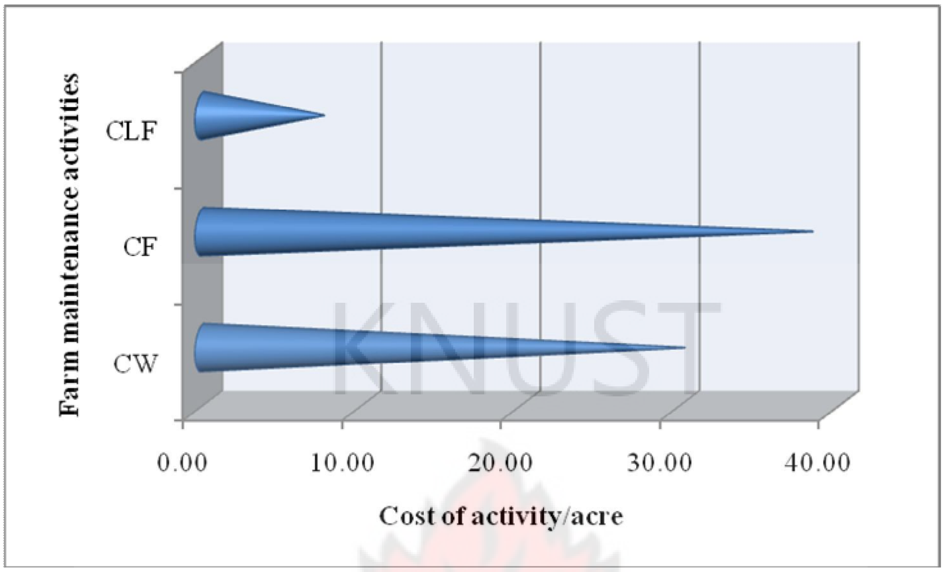
	FOREST ZONE		TRANSITION ZONE	
Activity	**Cost**	**% share of CP**	**Cost**	**% share of CP**
Stem cuttings	16.20	27.81	22.41	32.09
Transporting stem cuttings to planting field	11.40	19.57	14.07	20.14
Actual planting of cuttings	23.26	39.92	25.80	36.94
Sorting of stem cuttings	7.40	12.70	7.56	10.82
Cost of planting activities	**58.25**	**100.00**	**69.83**	**100.00**

Source: Field survey, 2010

4.4.3 Farm Maintenance

From the results, cost of farm maintenance was dominantly cost of manual weeding and fertilizer. About 33.4% of farmers in the study area apply fertilizer (Table 4.3.1). Cost of fertilizer was very high such that under cost of farm maintenance activities, it was the highest cost item (GH₵40/acre) with farmers applying about 2 bags/acre. Cost of manual weeding was the next most expensive item with GH₵ 29/acre and the cost of labour for fertilizer application being the least expensive (Fig 4.3).

Fig 4.3: Farm maintenance activity cost structure



Source: Field survey, 2010

CF=Cost of fertilizer CLF=Cost of labour for fertilizer application CW=Cost of weeding

Farm maintenance cost in the transition zone was higher than the forest. Cost of fertilizer in both zones was the highest cost item with expenditure on it being almost the same in both zones (Table 4.4.5). Cost of weeding was the item which did show some difference. This could be attributed to difference in vegetation cover.

Table 4.4.5: Comparing cost of farm maintenance activities/acre in the forest and transition zones

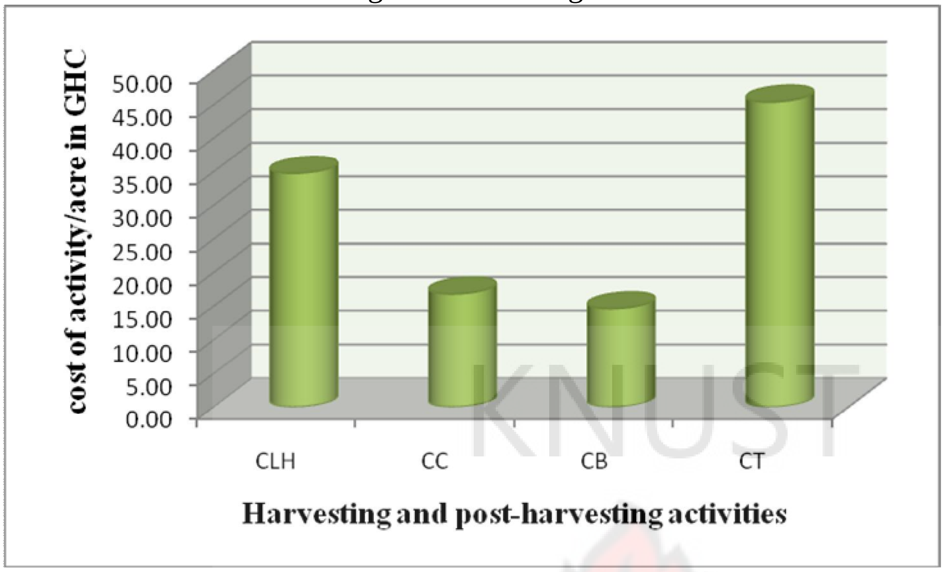
	FOREST ZONE		TRANSITION ZONE	
Activity	**Cost**	**% share of CFM**	**Cost**	**% share of CFM**
Weeding	29.48	39.10	31.27	40.44
Fertilizer	38.02	50.43	38.32	49.55
Labour for fertilizer application	7.90	10.47	7.74	10.01
Cost of farm maintenance	**75.40**	**100.00**	**77.33**	**100.00**

Source: Field, 2010

4.4.4 Harvesting and Post-Harvest Activities

From Fig 4.4, cost of transporting the produce to market centres was the most expensive activity under harvesting activities. Farmers spend GH₵ 45.40/acre for transporting 21bags of produce due to the remote nature of farms couple with bad roads. Labour cost for harvesting was the next expensive item costing GHC 34.73/acre with cost of carting the produce from the farm to the nearest road site for onwards transporting and bagging ranking 3rd and 4th respectively.

Fig 4.4: Harvesting activities cost structure



Source: Field survey, 2010

CLH=Cost of labour for harvesting roots CB=Cost of bagging CC=Cost of carting from farm to roadside CT= Cost of transporting produce

For harvesting activities, cost in the transition was higher than that of the forest with the exception of cost of labour for carting produce to the roadside. What is interesting is that in absolute values, costs of transporting produce from farms to market centres and labour for uprooting tubers were higher in the transition zone. In terms of percentages, that of labour for uprooting tubers was higher in the forest zone at 32.45% compared with 27.97% (Table 4.4.6). This was due to the fact that difference between cost of transportation in the two zones was very wide (Table 4.4.6).

Table 4.4.6: Comparing cost of harvesting activities/acre in the forest and transition zones

Activity	FOREST ZONE Cost(GH)	% share of CH	TRANSITION ZONE Cost(GH)	% share of CH
Labour for uprooting roots	30.24	32.45	35.79	27.97
Carting to roadside	15.19	16.30	15.46	12.08
Bagging	12.36	13.27	17.28	13.51
Transportation	35.40	37.99	59.43	46.44
Cost of harvesting activities(CH)	**93.19**	**100.00**	**127.97**	**100.00**

Source: Field survey, 2010

4.4.5 Input Cost Structure

Analysing cost of production in terms of inputs confirms the earlier assertion that labour was very important in cassava production. It is therefore not surprising that from Table 4.4.7, labour was the most expensive input to the farmer with a cost of GHC 238.64/acre, accounting for 59.17% of the farmers total input expenditure.

Table 4.4.7: Summary of input cost structure of cassava production/acre

Input(s)	**Cost**	**% Share of TC**
Labour (L)	238.64	59.17
Stem cuttings(SC)	23.20	5.75
Transportation (T)	59.66	14.79
Fertilizer (F)	38.34	9.51
Cutlass(C)	12.3	3.05
Hoe(H)	7.12	1.77
Sacks	15.28	3.83
Baskets	8.59	2.13
Total production cost(TPC)/acre	403.13	100

Source: Field survey 2010

Transportation cost which did comprise cost of transporting stem cuttings to the field as well as produce to market centres was the next expensive activity accounting for about 14.79% (GH₵ 59.66) of total production expenditure (Table 4.4.7).

The farmer spent less on fixed inputs comprising hoes, cutlasses, baskets and sacks averaging about 10% of total production expenditure. This is not very impressive since labour becomes less efficient due to lack of adequate working inputs and overall productivity is low. This explains the need to mechanise the industry to cut down cost of labour which is ever increasing.

4.5 Optimal Cost Minimisation Analysis

In order to investigate whether farmers in the study areas were minimising cost and operating at optimal levels for minimisation, the classical optimisation theory as well as Hessian determinants were used (Chiang and Wainwright, 2005). Regression models were specified and estimated for total cost of production as well as cost of various activities that constitutev total cost (Table 4.5.1 and 4.5.2).

4.5.1 Regression Results for Major and Sub-Activities

Correlation was high between total cost of production and expenditure on the major activities of production as well as major activities and sub-activities models. This explains why the independent variables consisting of farm maintenance cost, harvesting and post-harvet cost, land preparation and planting costs for the total cost model were all positively significant at 1% level of significance(Table 4.5.1).This was not different for the sub-activities models (Table 4.5.2). The positive relation means that as expenditure on major activities and sub-activities of production moves in a certain direction, total cost and major activity cost also responds in the same direction respectively. This means that as expenditure on the independent variables (major activities and sub-activities) decline, total cost and major activity cost also decrease respectively. Any attempt to decrease expenditure on the independent variables will therefore ensure a decrease in the dependent variables.

Table 4.5.1: OLS parameter estimates for total cost of cassava production in the forest and transition agro-ecological zones

Variable	Parameter	Coefficient	t-value
Constant	β_0	0.143830***	202.1433
Farm maintenance	β_1	0.648750***	12.46762
Harvesting activities	β_2	0.597221***	21.62527
Land preparation	β_3	0.776023***	16.28810
Planting activities	β_4	0.205682***	10.89259
R^2		0.882391	
F-statistic		695.8805***	

Source: Field survey 2010. Note***=1% level of significance

Table 4.5.2: Sub-activities within major activities OLS parameter estimates of cost of production in the forest and transition agro-ecological zones

Variable	Parameter	Coefficient	t-value
Land preparation			
Constant	α_0	0.180869***	196.2575
Land clearing	α_1	0.527766***	25.96292
Stumping	α_2	0.198269***	12.56072
Ridge making	α_3	0.387036***	19.37095
R^2		0.850736	
F-statistic		714.3422***	
Planting activities			
Constant	γ_0	0.188806***	105.2381
Stem cuttings	γ_1	0.342508***	19.72639
Transportation of stem cuttings	γ_2	0.106343***	12.49884
Labour for planting	γ_3	0.373041***	22.90061
Sorting of stem cuttings	γ_4	0.041290***	3.547537
R^2		0.782216	
F-statistic		336.7219***	
Farm maintenance			
Constant	ε_0	0.190716***	148.7464
Weeding	ε_1	0.447775***	33.69012
Fertilizer	ε_2	0.673943***	23.77069
Labour for fertilizer application	ε_3	0.042328***	6.551727
R^2		0.824093	
F-statistic		587.1647***	
Harvesting activities			
Constant	μ_0	0.171145***	113.9000
Labour for harvesting roots	μ_1	0.438256***	18.85997
Labour for carting produce	μ_2	0.147710***	7.310393
Bagging	μ_2	0.067666***	6.175918
Transportation of produce	μ_2	0.371702***	23.90084
R^2		0.851786	
F-statistic		538.7806***	

Note***=1% level of significance. Source: Field survey, 2010

Separate regression results for the two zones give an interesting picture. In terms of direction, a positive relation exists between the independent and dependent variables for the total cost model and sub- activities cost models for both zones. There is however differences in terms of magnitude of coefficients. The required change to cause a change in total cost is greater for all the major activities in the transition zone with the exception of farm maintenance (Table 4.5.3).This was due to higher percentage share of activities for the Transition zone except farm maintenance with 20.79% for the forest compared with 17.90% for the Transition zone (4.4.2).

Table 4.5.3: Comparing OLS parameter estimates in the forest and transition zones

Variable	Parameter	FOREST ZONE		TRANSITION ZONE	
		Coefficient	t-value	Coefficient	t-value
Constant	β_0	0.144819***	133.1508	0.141432***	126.4935
Land preparation	β_1	0.756671***	10.44078	0.848050***	12.69104
Planting activities	β_2	0.177288***	6.908507	0.329313***	9.531153
Farm maintenance	β_3	0.680662***	9.312721	0.489191***	5.884837
Harvesting and post-harvest activities	β_4	0.556459***	14.36759	0.781299***	15.83317
R^2		0.866495		0.831815	
F-statistics		295.3124***		232.4534***	

Note***=1% level of significance   Source: Field survey 2010.

Regression results for sub-activities for both zones did indicate a positive relation between major activities and sub-activities. However, some sub-activities were not significant in the Transition zone. Cost of labour for sorting stem cuttings was not significant in the Transition zone. This was due to the fact that sorting was mostly done by household labour. With just 5.2% (Table

4.3.2) of farmers applying fertilizer in the Transition zone, cost of fertilizer application was thus not significant. Generally, most of the sub-activities in the Forest zone had magnitudes greater than that of the Transition zone (Table 4.5.4). The Transition however had higher magnitudes for fixed cost. The general trend was that higher percentage share of cost (Tables 4.4.2 to 4.4.6) resulted in bigger magnitudes for zones (Table 4.5.4).

Table 4.5.4: Comparing Sub-activities Within major Activities OLS parameter Estimates of Cost of Production in the Forest and Transition Agro-ecological Zone

Variable	Parameter	FOREST ZONE		TRANSITION ZONE	
		Coefficient	t-value	Coefficient	t-value
Land preparation					
Constant	α_0	0.181504***	126.9290	0.186231***	106.5447
Land clearing	α_1	0.592775***	19.87716	0.548931***	14.07577
Stumping	α_2	0.152810***	10.17228	0.080494***	3.280453
Ridge making	α_3	0.379143***	11.04165	0.278375***	11.36975
R^2		0.852554		0.702038	
F-statistic		352.7110***		148.4362***	
Planting activities					
Constant	γ_0	0.198049***	94.97846	0.239596***	17.46009
Stem cuttings	γ_1	0.183496***	17.46694	0.099695***	9.430734
Transportation of stem cuttings	γ_2	0.049291***	5.187520	0.092352***	5.868055
Labour for planting	γ_3	0.454180***	14.24087	0.087343***	5.305384
Sorting of stem cuttings	γ_4	0.031834***	3.582340	-0.151674^{NS}	-1.399830
R^2		0.870164		0.555660	
F-statistic		304.9430***		58.77486***	
Farm maintenance					
Constant	ε_0	0.200947***	82.62230	0.198767***	24.21429
Weeding	ε_1	0.368597***	12.35507	0.170199***	13.49214
Fertilizer	ε_2	0.373889***	11.06084	0.901511***	2.920291
Labour for fertilizer application	ε_3	0.044796***	3.438222	0.011347^{NS}	0.262808
R^2		0.617626		0.496863	
F-statistic		98.52972***		62.21443***	
Harvesting and post harvest activities					
Constant	μ_0	0.181508***	74.60036	0.192540***	105.6305
Labour for harvesting roots	μ_1	0.279322***	9.434703	0.051083***	4.234896
Labour for carting produce	μ_2	0.101729***	4.814807	0.060071***	3.863857
Bagging	μ_3	0.024930*	1.734976	0.097152***	5.265615
Transportation of produce	μ_4	0.421995***	14.78135	0.152214***	6.258558
R^2				0.497080	
F-statistic				46.45425***	

Source: Field survey, 2010 Note***=1% level of significance, * =10% level of significance

4.5.2 Test of Hypothesis

From Table 4.5.5, the F statistic was highly significant at 1 percent for all the models. This means that all the explanatory variables in each of the models did jointly explain variation in the dependent variables. That is, total cost of production was jointly determined by the effect of expenditure on each of the major activities of production. This means that optimising each of these expenditure leads to minimization of total cost. Similar effect was realised when the effect of the sub-activities on the major activities was analyzed. Expenditure on the various sub-activities did jointly affect the cost of each major activity.

Table 4.5.5: Results of hypothesis test using the F-test

Model	Null Hypothesis	Alternate Hypothesis	F-statistic	Conclusion
Total cost of production model	H_0: β_{0-4}= 0	H_1: $\beta_{0-4}\neq 0$	695.8805***	H_0 is rejected in faviour of H_1
Land preparation model	H_0: β_{0-4}= 0	H_1: $\beta_{0-4}\neq 0$	714.3422***	H_0 is rejected in faviour of H_1
Planting activities model	H_0: β_{0-4}= 0	H_1: $\beta_{0-4}\neq 0$	336.7219***	H_0 is rejected in faviour of H_1
Farm maintenance model	H_0: β_{0-4}= 0	H_1: $\beta_{0-4}\neq 0$	587.1647***	H_0 is rejected in faviour of H_1
Harvesting activities model	H_0: β_{0-4}= 0	H_1: $\beta_{0-4}\neq 0$	538.7806***	H_0 is rejected in faviour of H_1

Source: Field Survey, 2010. Note***=1% level of significance

4.5.3 First and Second Order Conditions for Minimisation

A matrix was formed from the regression results taking them as the first derivatives and setting them to zero as the first order conditions for optimisation. Cramer's rule and Laplace expansion were used in finding the first order conditions (Dowling, 2001). A Hessian matrix was formed by taken the second derivates of the regression results and the signs of definiteness determined in concluding as to whether total cost of production as well as cost at each activity level was minimised or not.

From Table 4.5.5, the Hessian determinant matrices for each of the models proved to be a minimum point. This was due to the fact that the principal minors (H_1, H2, H_3, H_4) were positive definite satisfying the second order condition for minimisation. What this means is that, farmers did minimise cost of production at both the total cost level and cost at each activity level of production.

Table 4.5.5: Hessian determinant matrix for cost of cassava production in the transition and forest agro-ecological zones

Cost	**$\|H_1\|$**	**$\|H_2\|$**	**$\|H_3\|$**	**$\|H_4\|$**	**Sign**	**Decision**
TCCP	0.649	0.387	0.300	0.062	Positive definite	Minimised at the critical values
TCLP	0.528	0.105	0.040		Positive definite	Minimised at the critical values
TCP	0.343	0.036	0.014	0.0006	Positive definite	Minimised at the critical values
TCFM	0.448	0.302	0.013		Positive definite	Minimised at the critical values
TCH	0.438	0.065	0.004	0.0016	Positive definite	Minimised at the critical values

TCCP=Total cost of cassava production, TCLP=Total cost of land preparation TCP=Total cost of planting, TCFM=Total cost of farm maintenance, TCH=Total cost of harvesting, H_{1-4}=Hessian determinants

Source: Field survey 2010

The Hessian determinant matrix result was not different for the two zones. Each matrix was positive definite for both zones indicating farmers in both zones were cost minimisers. The differences that existed were in terms of magnitude of determinants (Table 4.5.6).

Table 4.5.6: Comparing Hessian Determinant Matrix for Cost of Cassava Production in the Transition and Forest zone

FOREST ZONE						
Cost	**$\|H_1\|$**	**$\|H_2\|$**	**$\|H_3\|$**	**$\|H_4\|$**	**Sign**	**Decision**
TCCP	0.757	0.134	0.091	0.051	Positive definite	Minimised at the critical values
TCLP	0.593	0.091	0.034		Positive definite	Minimised at the critical values
TCP	0.183	0.009	0.004	0.00013	Positive definite	Minimised at the critical values
TCFM	0.369	0.138	0.006		Positive definite	Minimised at the critical values
TCH	0.279	0.28	0.0071	0.0003	Positive definite	Minimised at the critical values
TRANSITION ZONE						
Cost	**$\|H_1\|$**	**$\|H_2\|$**	**$\|H_3\|$**	**$\|H_4\|$**	**Sign**	**Decision**
TCCP	0.848	0.279	0.136	0.107	Positive definite	Minimised at the critical values
TCLP	0.549	0.044	0.012		Positive definite	Minimised at the critical values
TCP	0.1	0.0009	0.00008		Positive definite	Minimised at the critical values
TCFM	0.17	0.153			Positive definite	Minimised at the critical values
TCH	0.05	0.003	0.0003	0.00004	Positive definite	Minimised at the critical values

TCCP=Total cost of cassava production, TCLP=Total cost of land preparation TCP=Total cost of planting, TCFM=Total cost of farm maintenance, TCH=Total cost of harvesting, H_{1-4}*=Hessian determinants*

Source: Field survey, 2010

4.5.4 Total Production Cost Minimisation Optimal Expenditure Levels

Farmers' total production cost comprises expenditure on land preparation, planting activities, farm maintenance and harvesting and post-harvesting activities. This gave an average Total Activity Cost (TAC) of GH₵ 358.79/acre and Total Cost of Cassava Production (TCCP) of GH₵ 402.08/acre when fixed cost is compensated (Table 4.5.8).

To minimise total production cost therefore means finding the optimal expenditure levels that will give the minimum total production cost. This can only be done when the function is proved to be minimum (Table 4.5.6). Since the Hessian determinant for total production cost is positive definite, total production cost is a minimum point. This means that for cassava farmers in the zone to operate at the optimal expenditure levels, they need to cut down total production expenditure by 11.2% which can be compared to Awoyemi (2006) who indicated farmers could cut down variable cost by 24.22%. Luclia et al; (2005) also indicated dairy farmers needed to cut down cost by 26% to be cost efficient. Ogundari et al; (2006) indicate small scale maize farmers in Nigeria wasted 16% of their resources.

In terms of activities cost, farm maintenance, harvesting and post-harvest, land preparation and planting activities need to be reduce by 14.7%, 14.4%, 13.7% and 14.3% respectively (Table 4.5.9). This would lead to a saving of GHC 51.11/acre since total production cost could go down from GHC 358.79/acre to 307.68/acre. By extension, a farmer with large acres will be saving more if he/she operates at the optimal levels.

Fixed cost (hoes, cutlass, baskets and sacks) however needed an upward adjustment of 14.4%. This would result in an increase in expenditure on fixed assets from GHC 43.29 to GHC 49.52. Compensating the needed upward adjustment in fixed cost means the farmer can still save GHC 44.88/acre if he/she operates at the optimal expenditure levels (Table 4.5.8).

Table 4.5.8: Optimal Cost Minimising Expenditure Levels for Major Activities

CCP_i	**$\lvert CCP_i \rvert$**	$\frac{1}{CA_i} = \frac{\lvert CCP_i \rvert}{\lvert CCP \rvert}$	$CA_i = \beta_i(1/CA_i)$	**% effect of** CA_i	**Average** CA_i	**Required** CA_i **adjustment**	**Optimal** CA_i
CCP	0.062		0.144	14.4	43.29	6.23	49.52
CLP	-0.011	-0.177	-0.137	-13.7	101.49	-13.90	87.59
CP	-0.043	-0.694	-0.143	-14.3	69.44	-9.93	59.51
CFM	-0.014	-0.226	-0.147	-14.7	76.29	-11.21	65.08
CH	-0.015	-0.242	-0.144	-14.4	111.57	-16.07	95.50
TAC				-14.2	358.79	-51.11	307.68
TCCP				-11.2	402.08	-44.88	357.20

CCP=Cost of cassava production matrix, i=cost of various activities of production, TAC=Total activity cost of production, TCCP=Total cost of cassava production CFM=Cost of farm maintenance CH= Cost of harvesting, CLP= Cost of land preparation CP= Cost of planting, CA=Cost of activity

Source: Field survey, 2010

4.5.5 Total Production Cost Minimisation Optimal Expenditure Levels Separating zones

Analysing each ecological zone separately showed that cassava farmers in the Forest zone spend less (GH₵ 362.65/acre) in production compared to those in the Transition zone (GH₵ 431.94/acre). Operating at an optimal level of GH₵ 332.73/acre and GH₵ 383.38/acre for the

Forest and Transition zones respectively will mean higher gains for farmers in the Transition zone. This is as a result of 48.56/acre (11.2%) savings for farmers in the Transition zone operating at the optimal level compared with GH₵29.92/acre (8.2%) for farmers in the Forest zone. (Table 4.5.9).

Table 4.5.9: Comparing optimal Expenditure Levels for Major Activities in Minimising Total Cost of Cassava Production in the Forest and Transition zones

CCP_i	FOREST ZONE				TRANSITION ZONE			
	Average CA_i (*GHC*)	Required CA_i adjustment	% effect of CA_i	Optimal CA_i	Average CA_i (*GHC*)	Required CA_i (*GHC*) adjustment	% effect of CA_i	Optimal CA_i (*GHC*)
CCP	43.03	6.24	14.5	49.27	43.54	6.14	14.1	37.40
CLP	92.79	-3.34	-3.6	89.45	113.62	-16.13	-14.2	97.49
CP	58.25	-8.50	-14.6	49.75	69.83	-9.85	-14.1	59.99
CFM	75.40	-11.08	-14.7	64.31	77.33	-10.98	-14.2	66.35
CH	93.19	-13.23	-14.2	79.95	127.61	-17.74	-13.9	109.87
TAC	**319.62**	**-36.16**	**-11.3**	**283.46**	**388.40**	**-54.70**	**-14.1**	**333.70**
TCCP	**362.65**	**-29.92**	**-8.25**	**332.73**	**431.94**	**-48.56**	**-11.2**	**383.38**

CCP=Cost of cassava production matrix, i=cost of various activities of production, TAC=Total activity cost of production, TCCP=Total cost of cassava production CFM=Cost of farm maintenance CH= Cost of harvesting and post-harvest, CLP= Cost of land preparation CP= Cost of planting, GHC=Ghana cedis

Source: Field survey, 2010.

4.5. 6 Cost of Land Preparation Minimisation Optimal Expenditure Level

A saving of GHC 15.19/acre is made under land preparation expenditure if farmers operate at optimal expenditure levels. This can be achieved by cutting down expenditure on land clearing, stumping and ridging by 18.5%, 18.3% and 18.4% respectively. This will lead to a reduction in cost of land preparation from GHC 120.74/acre to GHC 105.55/acre (Table 4.5.10).

Table 4.5.10: Optimal Expenditure Levels for Cost of Land Preparation in Cassava Production for the Transition and Forest Agro-Ecological Zones

CLP_i	$\lvert CLP_i \rvert$	$\frac{1}{LP_i} = \frac{\lvert CLP_i \rvert}{\lvert CLP \rvert}$	α_i	$CA_i = \alpha_i (1/LP_i)$	% effect of $LPAC_i$	Average $LPAC_i$ (GHC)	Require $LPAC_i$ adjustment (GHC)	Optimal $LPAC_i$ (GHC)
CLP	0.040		0.181	0.181	18.1	19.25	3.48	22.73
CLP_1	-0.014	-0.350	0.528	-0.185	-18.5	34.24	-6.33	27.91
CLP_2	0.037	-0.925	0.198	-0.183	-18.3	26.03	-4.76	21.27
CLP_3	-0.019	-0.475	0.387	-0.184	-18.4	41.22	-7.58	33.64
LPAC					-18.4	101.49	-18.67	82.82
TCLP					-12.6	120.74	-15.19	105.55

CLP=Constant, i=activities under land preparation, LPAC= Land preparation activity cost, TCLP=Total cost of land preparation CLP_1= Cost of land clearing, CLP_2 = Cost of stumping, CLP_3= Cost of ridging, CA=Cost of activity, GHC=Ghana cedis

Source: Field survey 2010.

4.5.7 Cost of Land Preparation Minimisation Optimal Expenditure Levels Separating zones

Comparing optimal expenditure levels on sub-activities to minimise cost of land preparation between the two zones showed that farmers in the Transition zone will need to reduce cost by 13.3% to operate at the optimal expenditure level of GH₵ 114.67/acre. This translated to a gain of GH₵ 17.54/acre compared with GH₵ 13.91/acre for farmers in the forest zone. This means that farmers in the transition gain more in terms of land preparation expenditure if optimal expenditure levels are adhered to (Table 4.5.11).

Table 4.5.11: Comparing Optimal Expenditure Levels for Cost of Land Preparation in Cassava Production for the Transition and Forest zones

CLP_i	FOREST ZONE				TRANSITION ZONE			
	Average $LPAC_i$	Require $LPAC_i$ adjustment	% effect of $LPAC_i$	Optimal $LPAC_i$	Average $LPAC_i$	Require $LPAC_i$ adjustment	% effect of $LPAC_i$	Optimal $LPAC_i$
CLP	19.93	3.63	18.2	23.55	18.59	3.46	18.6	22.05
CLP_1	31.32	-6.01	-19.2	25.31	37.92	-6.94	-18.3	30.98
CLP_2	26.15	-4.81	-18.4	21.34	25.67	-4.80	-18.7	20.87
CLP_3	35.33	-6.71	-19.0	28.61	50.03	-9.25	-18.5	40.77
LPAC	**92.79**	**-17.54**	**-18.9**	**75.26**	**113.62**	**-21.00**	**-18.5**	**92.63**
TCLP	**112.72**	**-13.91**	**-12.3**	**98.81**	**132.21**	**-17.54**	**-13.3**	**114.67**

CLP=Constant, i=activities under land preparation, LPAC= Land preparation activity cost, TCLP=Total cost of land preparation CLP_1= Cost of land clearing, C LP_2 = Cost of stumping, CLP_3= Cost of ridging/mounding

Source: Field survey, 2010

4.5.8 Cost of Planting Activity Minimisation Optimal Expenditure Levels

From Table 4.5.20, farmers can optimise cost of planting activities by cutting down expenditure on stem cuttings, transporting of stem cuttings, labour for planting and sorting of stem cuttings by 17.2%,17.7%,18.7% and 17.8%, respectively. This can reduce cost of planting activities from GHC 88.69/acre to GHC79.89/acre, leading to a saving of GHC 8.8/acre. This represents 9.9% of their cost should they operate at the optimal level (Table 4.5.12).

Table 4.5.12: Optimal Expenditure Levels for Cost of Planting Activities in Cassava Production for the Transition and Forest zone

CP_i	$\|CP_i\|$	$\frac{1}{P_i} = \frac{\|CP_i\|}{\|CP\|}$	γ_i	$CA_i = \gamma_i(1/P_i)$	% effect of ACP_i	Average ACP_i	Require ACP_i adjustment	Optimal ACP_i
CP	0.0006		0.189	0.189	18.9	19.25	3.64	22.89
CP_1	-0.0003	-0.5000	0.343	-0.172	-17.2	23.15	-3.98	19.17
CP_2	-0.0010	-1.6667	0.106	-0.177	-17.7	13.26	-2.35	10.91
CP_3	-0.0003	0.5000	0.373	-0.187	-18.7	25.27	-4.73	20.54
CP_4	-0.0026	-4.3333	0.041	-0.178	-17.8	7.76	-1.38	6.38
ACP					-17.9	69.44	-12.44	57.00
TCP					-9.9	88.69	-8.8	79.89

CP=Constant, i=activities under planting activities ACP=Activity cost of planting TCP=Total cost of planting CP_1=cost of stem cuttings, CP_2= cost of transporting stem cuttings, CP_3=cost of labour for planting, CP_4=cost of sorting stem cuttings

Source: Field survey, 2010.

4.5.9 Cost of Planting Minimisation Optimal Expenditure Levels Separating zones

Farmers in the transition zone stand to benefit more when they operate at the optimal expenditure level for planting activities. Cost of planting activities will be reduced by 12.97% compared with 9.9% for farmers in the forest zone. The highest gain for famers in the transition in terms of planting activities will be cost of transporting stem cuttings to planting fields been reduced by 24.2%. That of the Forest zone will be reducing cost of labour for planting stem cuttings, by 20.9% (Table 4.5.13).

Table 4.15.13: Comparing optimal expenditure levels for cost of planting activities in cassava production for the transition and forest zones

CP_i	FOREST ZONE				TRANSITION ZONE			
	Average ACP_i	Require ACP_i adjustment	% effect of ACP_i	Optimal ACP_i	Average ACP_i	Require ACP_i adjustment	% effect of ACP_i	Optimal ACP_i
CP	19.93	3.95	19.8	23.87	18.59	4.46	24.0	23.05
CP_1	16.20	-3.21	-19.8	12.99	22.41	-5.38	-24.0	17.03
CP_2	11.40	-2.14	-18.8	9.26	14.07	-3.40	-24.2	10.66
CP_3	23.26	-4.86	-20.9	18.40	25.80	-6.17	-23.9	19.63
CP_4	7.40	-1.47	-19.9	5.92	NS	NS	NS	NS
ACP	**58.25**	**-11.68**	**-20.1**	**46.57**	**62.28**	**-14.95**	**-24.0**	**47.33**
TCP	**78.18**	**-7.74**	**-9.9**	**70.44**	**80.87**	**-10.49**	**-12.97**	**70.38**

CP=Constant, i=activities under planting activities ACP=Activity cost of planting TCP=Total cost of planting CP_1=cost of stem cuttings, CP_2= cost of transporting stem cuttings, CP_3=cost of labour for planting, CP_4=cost of sorting stem cuttings

Source: Field survey 2010.

4.5.10 Cost of Farm Maintenance Minimisation Optimal Expenditure Levels

Cassava farmers can save GHC 10.93/acre, representing 11.4% of farm maintenance cost by operating at the optimal expenditure level. This will ensure cost of farm maintenance is minimised at GHC 84.61/acre as compared to the initial average cost of GHC 95.54/acre. To achieve this will mean cutting down expenditure on weeding, fertilizer and labour for fertilizer application by 17.2%, 20.8% and 18.7% respectively (Table 4.5.14)

Table 4.5.14: Optimal expenditure levels for cost farm maintenance in cassava production for the transition and forest agro-ecological zones

CFM_i	$\|CFM_i\|$	$\frac{1}{FM_i} = \frac{\|CFM_i\|}{\|CFM\|}$	ε_i	$CA_i = \varepsilon_i(1/FM_i)$	% effect of CA_i	Average $ACFM_i$ (GHC)	Require $ACFM_i$ adjustment (GHC)	Optimal $ACFM_i$ (GHC)
CFM	0.013		0.191	0.191	19.1	19.25	3.68	22.93
CFM_1	-0.005	-0.385	0.448	-0.172	-17.2	30.31	-5.21	25.1
CFM_2	-0.004	-0.308	0.674	-0.208	-20.8	38.34	-7.97	30.37
CFM_3	-0.058	-4.462	0.042	-0.187	-18.7	7.64	-1.43	6.21
ACFM					-19.2	76.29	-14.61	61.68
TCFM					-11.4	95.54	-10.93	84.61

CFM= Constant, i=activities under farm maintenance, ACFM= Activity cost of farm maintenance, TCFM=Total cost of farm maintenance CFM_1=Cost of weeding CFM_2= Cost of fertilizer CFM_3=cost of labour for fertilizer application

Source: Field survey, 2010.

4.5.11 Cost of Farm Maintenance Minimisation Optimal Expenditure Levels separating zones

Minimising cost of farm maintenance will lead to a reduction in total farm maintenance cost by 11.5% and 10.7% in the transition and forest zones respectively. The average cost/acre for farm maintenance at the optimal level in the forest zone was greater than the transition (Table 4.5.15). This was due to the fact that cost of labour for fertilizer application in the transition was not significant (Table 4.5.4). Only 5.2% of cassava farmers in the transition zone were applying fertilizer and thus cost of labour in fertilizer application did not influence cost of farm maintenance (Table 4.2.3).

Table 4.5.15: Comparing optimal expenditure levels for cost of farm maintenance in cassava production for the transition and forest zones

CFM_i	FOREST ZONE				TRANSITION ZONE			
	Average $ACFM_i$ (GHC)	Require $ACFM_i$ adjustment (GHC)	% effect of CA_i	Optimal $ACFM_i$ (GHC)	Average $ACFM_i$ (GHC)	Require $ACFM_i$ adjustment (GHC)	% effect of CA_i	Optimal $ACFM_i$ (GHC)
CFM	19.93	3.99	20.0	23.91	18.59	3.70	19.9	22.29
CFM_1	29.48	-5.45	-18.5	24.02	31.27	-6.22	-19.9	25.05
CFM_2	38.02	-7.11	-18.7	30.91	38.32	-7.66	-20.0	30.66
CFM_3	7.90	-1.66	-21.0	6.24	NS	NS	NS	NS
ACFM	**75.40**	**-14.22**	**-18.9**	**61.17**	**69.59**	**-13.89**	**-20.0**	**55.70**
TCFM	**95.32**	**-10.24**	**-10.7**	**85.09**	**88.18**	**-10.19**	**-11.5**	**77.99**

CFM= Constant, i=activities under farm maintenance, ACFM= Activity cost of farm maintenance, TCFM=Total cost of farm maintenance CFM_1=Cost of weeding CFM_2= Cost of fertilizer CFM_3=cost of labour for fertilizer application

Source: Field survey, 2010

4.5.12 Cost of Harvesting and Post-Harvest Minimisation Optimal Expenditure Levels

The required adjustment in sub-activities in minimizing cost of harvesting and post-harvest activities is a downward cut in such activities leading to a total cut in cost of harvesting and post-harvest by GHC 12.23/acre. This creates some savings for the farmer which can be used for other activities to enhance the overall efficiency of the farmer. This can be achieved by spending GHC 29.0/acre, GHC 13.87/acre, GHC 12.08/acre and 36.96/acre on labour for harvesting roots, carting of produce from farm to roadside, bagging and transporting produce to market centers respectively (Table 4.5.16).

Table 4.5.16: Optimal Expenditure Levels for Cost Harvesting and Post-Harvest Activities in Cassava Production for The Transition and Forest zones

CH_i	$\lvert CH_i \rvert$	$\frac{1}{H_i} = \frac{\lvert CH_i \rvert}{\lvert CH \rvert}$	μ_i	$CA_i = \varepsilon_i (1/H_i)$	% effect of ACH_i	Average ACH_i	Require ACH_i adjustment	Optimal ACH_i
CH	0.0016		0.171	0.171	17.1	43.29	7.40	50.69
CH_1	-0.0006	-0.375	0.438	-0.164	-16.4	34.73	-5.70	29.03
CH_2	0.0019	-1.188	0.148	-0.175	-17.5	16.81	-2.94	13.87
CH_3	0.0041	-2.563	0.068	-0.174	-17.4	14.63	-2.55	12.08
CH_4	-0.0008	0.500	0.372	-0.186	-18.6	45.40	-8.44	36.96
ACH						111.57	-19.63	91.94
TCH						154.86	-12.23	142.63

CH=Constant, i= Sub-activities under harvesting activities, ACH=Activity cost of harvesting TCH=Total cost of harvesting, CH_1= Cost of labour for uprooting roots, CH_2= Cost of carting produce to roadside, CH_3=Cost of bagging produce, CH_4=Cost of transporting produce

Source: Field survey 2010

4.5.13 Cost of Harvesting and Post-Harvest Minimisation Optimal Expenditure Levels Separating zones

To operate at optimal harvesting and post-harvest expenditure, farmers will have to reduce cost by 11.5% and 5.6% in the transition and forest zones respectively. The highest reduction in the transition zone will be cutting down expenditure on transportation by 22.8% in the Transition zone. For the Forest zone, cost of labour for uprooting roots from the ground requires the highest cut of 18.6%. If farmers operate at optimal levels, total savings in each will be GH₵ 7.63/acre and GH₵ 19.79/acre for the forest and transition zones respectively (Table 4.5.17).

Table 4.5.17: Comparing Optimal Expenditure Levels for Cost Harvesting and Post-Harvest Activities in Cassava Production for the Transition and Forest zones

CH_i	FOREST ZONE				TRANSITION ZONE			
	Average ACH_i	Require ACH_i adjustment	% effect of ACH_i	Optimal ACH_i	Average ACH_i	Require ACH_i adjustment	% effect of ACH_i	Optimal ACH_i
CH	43.03	7.83	18.2	50.86	43.54	8.40	19.3	51.95
CH_1	30.24	-5.62	-18.6	24.61	35.79	-7.62	-21.3	28.17
CH_2	15.19	-2.58	-17.0	12.60	15.46	-3.25	-21.0	12.22
CH_3	12.36	-2.26	-18.3	10.10	17.28	-3.77	-21.8	13.52
CH_4	35.40	-4.99	-14.1	30.41	59.43	-13.55	-22.8	45.88
ACH	93.19	-15.46	-16.59	77.73	127.97	-28.19	-22.0	99.78
TCH	136.22	-7.63	-5.6	128.59	171.52	-19.79	-11.5	151.73

CH=Constant, i= Sub-activities under harvesting activities, ACH=Activity cost of harvesting TCH=Total cost of harvesting, CH_1= Cost of labour for uprooting roots, CH_2= Cost of carting produce to roadside, CH_3=Cost of bagging produce, CH_4=Cost of transporting produce

Source: Field survey 2010

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter brings to closure conclusions on research findings and makes recommendations necessary for reducing cost and ensuring efficiency in the cassava industry as a whole.

5.2 Summary

The main objective of identifying and analysing key inputs, activities and optimal expenditure levels that minimises farmers' total cost of production as well as cost at each major activity level was achieved. This was through the conduct of a formal survey using structured questionnaires. Activities and cost involve in the production process as well as inputs farmers perceive as most important were analysed using descriptive statistics. Production expenditure levels required for optimal Cost minimization was estimated using classical optimation theory. This was through establishing the first and second order conditions for optimisation and evaluating the stationary points using the Hessian determinants matrix.

5.3 Conclusion

From this study, it can be concluded that cassava production involve mainly four major activities. These include; land preparation, planting, farm maintenance and harvesting and post-harvest activities. These major activities also involve sub-activities which are undertaken by every farmer or some farmers. Activities undertaken by every farmer were land clearing, actual planting of stem cuttings, weeding and harvesting. Other activities such as; stumping, ridging/mounding, fertilizer application, sorting of stem cuttings, bagging and transporting produce to market centres were not undertaken by every farmer. About 57.1% of farmer did stumping. This was particular with virgin lands. Riding/mounding was done by 50.3% with the rest of farmers planting on the flat land. Fertilizer application was done by 33.4% in an attempt to boost soil fertility. Sorting of stem cuttings, bagging and transporting produce to market centres were done by 87.4%, 57.9% and 78.4%.

Total production cost/acre was estimated as GH₵ 402.08. Out of this, cost of harvesting and post- harvest activities took the greater percentage (27.75%). However, cost of land preparation had the greatest effect (0.776) on total cost of production upon estimating the total cost of production function. Total cost of production was high in the Transition zone (GH₵431.94) than the Forest zone (GH₵ 362.65).

For the quantitative aspect of the study, it can be concluded that cassava farmers in the Forest and Transition agro-ecological zones of Ghana are cost minimisers. This is due to the nature of their total production cost function, which proved to be minimum by the use of classical optimisation theory. The Hessian determinant matrix was positive definite satisfying the second order sufficient condition for minimisation.

Farmers in the two agro-ecological zones however did not operate at the optimal expenditure level. This was because their expenditure on various activities that constitute their total production cost function was either above or below the optimal expenditure level required.

Generally, cassava farmers in the two zones are required to operate at an optimal production expenditure level of 357.20/acre. That is reducing their present cost (GH₵ 402.08) by 11.2%. However, the two zones are face with different conditions and analysing them separately reveled that total cost of production in the Transition zone is higher than the Forest zone. About 11.2% reduction in total production cost is required to obtain an optimal expenditure of GHC 383.38/acre. The Forest zone will require 8.25% reduction in current total production cost to attain the optimal level of GHC 332.73/acre. Achieving this will mean adjusting expenditure on various activities.

It is clear cassava farmers in the two zones are over spending as far as variable cost is concern and not spending much on fixed inputs. This clearly does not offer opportunity to optimise and save capital for other activities. To optimise will mean cutting down expenditure on land preparation, planting, farm maintenance and harvest and post-harvest activities. Expenditure on fixed (i.e; cutlasses, hoes, baskets and sacks) assets would however be required to increase to avoid overutilization and ensure efficiency and optimal cost of production.

It was also realised labour was the most expensive input in the production process. This is due to the lack of mechanisation in the production process with heavy reliance on labour. This explains why cost of harvesting activities was the highest activity cost since the main components were labour and transportation both with huge expenditure levels. This brings to mind the need for mechanisation and provision of good roads to reduce harvesting activity cost. This will help reduce total cost of production and increase farmer profit and reduce commodity price.

5.4 Recommendation

Based on the findings of this study, it is recommended that farmers re-alien their expenditure structure in accordance with the various optimal levels to ensure that total cost of production is minimised. The need to analyse their expenditure distribution is vey key rather than just spending on activities without bearing in mind the need for minimisation. This will ensure low production cost and increase net gains from their activities.

Efficiency of labour needs to be enhanced if cassava production cost is to be minimised. Labour is intensively used but contributes little in minimising the cost of the cassava production. Farmers therefore should intensify their supervision role of labour to ensure efficiency and increase productivity.

Agricultural researchers as well as policy should find a way of mechanizing the production process. This will be a great breakthrough in reducing the cost of cassava farmers. Simple forms of mechanisation in terms of encouraging farmers to plant on ridges and use of fertilizer will help boost yield. Animals like bullocks and donkeys can be employed in ploughing and use of riggers for other activities. This will go a long way in reducing the labour intensive nature of production. Developing a simple machine for uprooting roots from the ground will be a great relief to the farmer.

5.4 Suggestions for Further Research

From the study, labour is not efficient and need for further studies to establish the efficiency of labour in cassava production. Again a research to establish standards in the cassava industry are eminent, this is necessary as it will bring uniformity into the cost of labour and other expenditure items in cassava production. Further research to cover the entire nation is as well necessary for the purposes of generalisation.

REFERENCES

Awoyemi Taiwo Timothy, 2006. Department of Agricultural Economics, University of Ibadan, Ibadan, Nigeria

Adams, CD. 1957. Activities of Danish Botanists in Guinea 1738–1850. Transactions of the Historical Society of Ghana III. Part 1.

Alpha C. Chiang and Kevin Wainwright, 2005.Fundamental Methods of mathematical Economics

Arthur A. Thompson Jr, 1973. Economics of the Firm, Theory and practice. 5th edition. Prentice Hall, Englewood Cliff, New Jersey.

Allen M. Featherstone, Ghassan A. Moghnieh, Barry K. Goodwin, 1995. Farm-Level nonparametric analysis of cost-minimisation and profit-maximisation behavior. Agricultural economics 13(109-117), Elsevier.

Adeleke, O. A, Y . L Fabiyi A. Ajiboye and H.M Matanmi, 2008. Application of Stochastic Production Frontier in the Estimation of Technical Efficiency of Female Cassava Farmers in Ibadan/Ibarapa Agricultural Zone of Oyo State, Nigeria. Agricultural Journal 3(5).

Briggs H. Andrew and Bernie J. O'Brien, 2000. The death of cost-minimisation analysis. Journal of Health Economics 10(2) pp 179-184

Damordar N.Gujarati. Basic Econometrics 4th Edition, 2004.McGraw-Hill.

Edward T.Dowling, 2001.Theory and Problems of Introduction to Mathematical Economics

FAO, 2000. Review of cassava in Africa with country case studies on Nigeria and Ghana-Cassava Development in Ghana.

FAO- Economic and Social Department, 2000. State of Food Insecurity in the World.

Government of Ghana, International Labour Organisation and United Nations Development Programme, 2004. An Employment Framework for Poverty Reduction in Ghana.

Ghana Statistical Service, 1989. Ghana Living Standards Survey Report on the First Round (GLSS 1) September 1987 - August 1988.

Ghana Statistical Service. 1995. Ghana Living Standards Survey Report on the Third Round (GLSS 3) September 1991 - September 1992.

Henderson M. James and Richard E. Quandt,1980. Microeconomic theory, a mathematical approach.3 edition,McGraw-Hill Publishing.

IFPRI &PBS, 2007. Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana. Brief No. 5 Of 5

James D.E and C.D Throsby, 1984. Introduction to Quantitative methods in Economics. John Willey and Sons publications.

Jones, W.O. 1959. Manioc in Africa. Stanford University Press 1959.

Jonathan Cagan and Brian C.Williams, 1993. First Order necessary Conditions for Robust

Lucila Ma, A. Lapar1, Alexis Garcia, Satit Aditto, and Patcharee Suriya, 2006. Measuring Cost Efficiency in Smallholder Dairy: Empirical Evidence from Northeast Thailand. Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27.

MoFA, 1995. Facts and Figures of Ghana Agriculture.

MoFA, April 2010.Agricuture in Ghana (Facts and figures)

MoFA, 2008. Crop Budget for coastal savannah and Forest ecological zones

MoFA, 2005. Statistics, Research and Information Directorate (SRID), Cropped Area for major food production in Ghana

MoFA, 2005. Statistics, Research and Information Directorate (SRID), Production of major crops in Ghana

MoFA, 2009.Agriculture in Ghana, Facts and Figures

Ojeda B., LM de Sande, A Casado, P Merino and MA Casado, 2003. Cost-minimisation analysis of pegylated liposomal doxorubicin hydrochloride versus topotecan in the treatment of patients with recurrent epithelial ovarian cancer in Spain. British Journal of Cancer (89), 1002 – 1007.

Optimality Proceedings DE-Vol. 65-1, Advances in Design Automation, Vol. 1, pp 539-5 Ogundari. K, S.O. Oj and I.A. Ajibefun, 2006. Economies of Scale and Cost Efficiency in Small Scale Maize Production: Empirical Evidence from Nigeria. Journal of Social Science. 13(2): 131-136

Root and Tuber Improvement Programme-Ghana, 2004. Interim evaluation Report #1533-GH

www.ghanadistrits.com

Appendix I: 2008 TOTAL NUMBER OF CASSAVA HOLDERS CULTIVATING IN VARIOUS DISTRICTS, GHANA.

WESTERN		EASTERN		ASHANTI		BRONG AHAFO	
DISTRICT	**TNHC**	**DISTRICT**	**TNHC**	**DISTRICT**	**TNHC**	**DISTRICT**	**TNHC**
Shama Ahanta East	35,552	Birim South	34,212	Amansie East	29,130	Sunyani	
West Ahanta	19,671	West Akim	23,139	Amansie west	14,475	Tain	4,517
Mporhor Wassa East	15,328	Suhum/Kraboa/Coalta	32,057	Amansie Central	18,993	Asutifi	2,263
Wassa West	44,584	Akwapim South	25,942	Ejura Sekyeredumase	4,043	Wenchi East	14,255
East Nzema	31,154	Akwapim North	26,341	Sekyere West	17,039	Dormaa	54,567
Jomoro	12,365	New Juabeng	11,328	Sekyere East	27,097	Berekum	22,545
Amenfi East	14,343	Yilo Krobo	16,850	Afigya Sekyere	29,997	Tano North	4,365
Amenfi West	12,844	East Akim	17,577	Ahafo Ano North	8,360	Tano South	6,776
Aowin – Suaman	14,599	Kwaebibirem	27,025	Ahafo Ano South	21,964	Sene	8,320
Bibiani-Anwiaso-Bekwai	23,730	Birim North	35,086	Atwima Mponua	18,088	Nkoranza	10,522
Sefwi Wiaso	16,159	Kwahu West	14,195	Atwima Nwabiagya	21,682	Pru	9,043
Juabeso	9,835	Kwahu South	19,646	Ejisu Juabeng	21,344	Techiman	30,921
Bia	8,920	Fanteakwa	23,953	Bosomtwe-Atwima-Kwanwoma	19,348	Asunafo North	17,534
		Afram Plains	11,889	Kwabre	27,601	Asunafo South	5,514
		Asuogyaman	12,375	Offinso	9,942	Jaman North	4,904
		Manya Krobo	27,750	Adansi North	17,422	Jaman South	14,527
		Atiwa	17,368	Adansi South	15,495	Kintampo North	4,867
				Obuasi Municipal	5,018	Kintampo South	3,209
				Asante Akim North	19,882	Atebubu Amantin	10,713
				Asante Akim South	25,411		
				K.M.A	6,683		
TOTAL	**259,084**		**376,733**		**379,014**		**242,149**

Continuation of Appendix I

NORTHERN		GREATER ACCRA		CENTRAL		VOLTA	
DISTRICT	**TNHC**	**DISTRICT**	**TNHC**	**DISTRICT**	**TNHC**	**DISTRICT**	**TNHC**
West Gonja	7,695	Tema	2,837	Upper Denkyira	15,583	North Tongu	17,157
Central Gonja	12,191	Ga East*	35,770	Twifo-Herman/L. Denkyira	15,357	South Tongu	4,346
Yendi	14,507	Ga West	4,757	Assin North	12,987	Akatsi	4,961
Nanumba North	14,128	West Dangme	9,513	Assin South	7,078	Keta	10,109
Nanumba South	24,472	East Dangme	-	Abura-Asebu-Kwamankese*	12,838	Ketu	40,003
Gushiegu	5,748	A.M.A		Asikuma-Odoben-Brakwa	9,516	North Dayi(Kpando)	6,402
Karaga	1,615			Mfantsiman	12,811	South Dayi	6,063
East Mamprusi	116			Komenda-Edina-Eguafo-Abirem	8,332	Hohoe	27,942
Bunkpurugu Yunyoo	118			Ajumako-Essiam-Enyan	13,574	Jasikan	16,318
Savelugu/Nanton	4,070			Awutu-Efutu-Senya	16,705	Kadjebi	12,072
East Gonja	46,698			Gomoa	16,221	Nkwanta	23,797
Tamale Metropolitan	7,280			Cape Coast	22,722	Krachi West	8,754
Bole	4,612			Agona	15,478	Krachi East	12,867
Sawla-Tuna-Kalba	6,821					Ho	27,553
Saboba/Chereponi	238					Adaklu Anyigbe	557
Tolon/Kumbungu	8,868						
West Mamprusi	99						
Zabzugu/Tatale	11,404						
TOTAL	**170,677**		**65,601**		**179,202**		**218,901**

Source: MoFA, Basic agricultural Statistics-2008

Appendix II: CROPPED AREA FOR MAJOR CROPS IN GHANA (FIGURES IN HECTARES)

YEAR	MAIZE	RICE	MILLET	SORGHUM	CASSAVA	YAM	COCOYAM	PLANTAIN	G'NUTS	COWPEA
1997	651635	117722	170000	323600	589281	187443	206224	224773	159800	78900
1998	696621	130393	180733	332363	629683	210915	217767	245917	176773	97916
1999	699730	107097	171265	298057	640341	240186	261783	200421	158550	86530
2000	694735	115156	208348	288706	660091	261041	247462	244406	217860	90759
2001	713303	135321	192979	329103	726357	287386	262418	265128	254497	101548
2002	890690	119120	206560	346020	812150	326130	285300	285440	504710	190350
2003	791910	117720	206560	346030	807240	321410	276670	286460	464710	190350
2004	732955	119392	182232	298107	783947	310884	269546	281192	431667	183426
2005	966498	161339	175669	290999	921450	362907	201913	354381	308951	133852
Average	759786	124807	188261	316998	730060	278700	247676	265346	297502	128181

Source: Compiled from PPMD and SRID(MoFA) Various Issues

Appendix III: PRODUCTION OF SOME MAJOR CROPS IN GHANA: 1997-2005(FIGURES IN METRIC TONS)

YEAR	MAIZE	RICE	MILLET	SORGHUM	CASSAVA	YAM	COCOYAM	PLANTAIN	G'NUTS	COWPEA
1997	995953	197063	143480	332613	6999534	2407938	1529798	1818377	139680	59070
1998	1015029	281111	162269	355419	7171452	2702857	1576687	1912648	193171	70379
1999	974220	206988	164990	299215	7685648	3801586	1733543	1954518	153990	74187
2000	1012700	248694	169377	279784	8106758	3362909	1625088	1932471	208638	63285
2001	937973	274596	134370	279712	8965840	3546739	1687506	2073884	286792	62542
2002	1256580	242740	175740	337670	10255910	3832670	1826380	2329010	489030	145590
2003	1288600	238810	175740	337670	10239340	3812840	1804650	2328600	439030	145590
2004	1157621	241807	143798	287385	9738812	3892259	1715864	2380858	389649	141482
2005	1657710	306999	148102	278298	13808144	4604666	1539626	3571964	337025	91671
Average	1144043	248756	157541	309752	9219049	3551607	1671016	2255814	293001	94866

Source: Compiled from PPMD and SRID(MoFA) Various Issues

Appendix IV: AVERAGE YEILD OF MAJOR CROPS IN GHANA: 1997-2005(FIGURES IN MT/HA)

	MAIZE	RICE	MILLET	SORGHUM	CASSAVA	YAM	COCOYAM	PLANTAIN	G'NUTS	COWPEA
1997	1.5	1.7	0.8	1.0	11.9	12.8	7.4	8.1	0.9	0.7
1998	1.5	2.2	0.9	1.1	11.4	12.8	7.2	7.8	1.1	0.7
1999	1.4	1.9	1.0	1.0	12.0	15.8	6.6	9.8	1.0	0.9
2000	1.5	2.2	0.8	1.0	12.3	12.9	6.6	7.9	1.0	0.7
2001	1.3	2.0	0.7	0.8	12.3	12.3	6.4	7.8	1.1	0.6
2002	1.4	2.0	0.9	1.0	12.6	11.8	6.4	8.2	1.0	0.8
2003	1.6	2.0	0.9	1.0	12.7	11.9	6.5	8.1	0.9	0.8
2004	1.6	2.0	0.8	1.0	12.4	12.5	6.4	8.5	0.9	0.8
2005	1.7	1.9	0.8	1.0	15.0	12.7	7.6	10.1	1.1	0.7
Average	1.5	2.0	0.8	1.0	12.5	12.8	6.8	8.5	1.0	0.7

Source: Compiled from PPMD and SRID(MoFA) Various Issues

Appendix V: CROPPED AREA FOR CASSAVA ON REGIONAL BASIS IN GHANA: 1997-2005

Region	WESTERN	CENTRAL	EASTERN	GT. ACCRA	VOLTA	ASHANTI	BRONG-AHAFO	NORTHERN	U.WEST	U.EAST
1997	60944	60093	165000	12092	56800	117462	94390	22500	-	-
1998	65400	62700	186000	10883	65655	116863	97532	24650	-	-
1999	67328	65310	167400	10273	65555	118934	120441	25100	-	-
2000	69834	78561	150000	10787	67150	124795	126464	32500	-	-
2001	71929	80132	180000	11320	69500	128539	132787	52150	-	-
2002	74290	110030	182000	7750	72000	129000	171020	66060	-	-
2003	74290	110030	183300	7750	72000	122780	171030	66060	-	-
2004	73954	106729	171730	8029	77300	120324	170150	55730	-	-
2005	74946	126103	234237	8020	81000	146891	179826	70427	-	-
Average	70324	88854	179963	9656	69662	125065	140404	46131		

Source: Compiled from PPMD and SRID (MoFA) Various Issues

Appendix VI: CROP BUDGET FOR THE COASTAL SAVANNA AND FOREST AGRO-ECOLOGICAL ZONES

CROP BUDGET 2008			
Crop : . . . CASSAVA			
Technology . . . .TRADITIONAL		Ecological Zone. . COASTAL SAVANNA	
ITEM / ACTIVITY	QTY OF RESOURCE	UNIT COST (¢)	TOTAL COST (¢)
			Per Acre
A. LABOR INPUT:	Mandays unless other wise stated	Cost/manday/contract	
1. Land Clearing (new land) dep.over 20 yrs)	Contract	200	10.0
2. Land preparation			
- manual field cleaning	3	2	6.0
3. Planting	5	3	15.0
4. Weeding :			
- 1st	5	4	20.0
-2nd	4	4	16.0
5. Harvesting	10	4	40.0
6. Bagging	2	2	4.0
7. Transportation	No. of Unit(s)	Unit cost	
- carting of produce(bags)	60	0.5	30.0
Sub - Total (A)			141.0
B. LAND RENT:	Per acre	20	20.0
C. VARIABLE INPUT	No. of Unit(s)	Unit cost	
- cassava sticks, bundles	15	2	30.0
Sub - Total (C)			30.0
D. TOOLS & EQUIPMENT			
- cutlass (depreciated over 2 yrs)	1	3.8	1.9
- hoe (depreciated over 2 yrs)	1	3.9	2.0
- sacks (depreciated over 2 seasons)	15	0.45	3.4
- basket (depreciated over 2 seasons)	5	0.5	1.3

Sub - Total (D)			8.5
E. TOTAL (A+B+C+D)			199.5
F. Contigency (5% of E)			10.0
G. TOTAL (E+F)			209.4
H. Interest :			
- Bank rate, 25% p.a			52.4
GRAND TOTAL			261.8
REVENUE			
Yield / ac . . . (mt)			6.0
Price (cedis)/ unit of produce…			80.0
Gross Revenue			480.0
Net Revenue			218.2
Return on Investment, %			83.3
CROP BUDGET 2008			
Crop : . . . CASSAVA			
Technology . . . TRADITIONAL		Ecological Zone . . FOREST	
ITEM / ACTIVITY	QTY OF RESOURCE	UNIT COST (¢)	TOTAL COST (¢)
			Per Acre
A. LABOR INPUT:	Mandays unless other wise stated	Cost/manday/contract	
1. Land Clearing (new land) dep.over 20 yrs)	Contract	240	12
2. Land preparation			
- manual field cleaning	10	2	20
3. Planting	5	3	15
4. Weeding :			
- 1st	7	3.5	24.5
-2nd	6	3.5	21

5. Harvesting	10	3	30
6. Bagging	2	2	4
7. Transportation	No. of Unit(s)	Unit cost	
- carting of produce(bags)	80	0.5	40
Sub-Total (A)			154.5
B. LAND RENT:	Per acre	25	25
C. VARIABLE INPUTS	No. of Unit(s)	Unit cost	
- cassava sticks, bundles	15	3	45
SUB-TOTAL (C)			45
D. TOOLS & EQUIPMENT			
- cutlass (dpreciated over 2 yrs)	1	3	1.5
- hoe (depreciated over 2 yrs)	1	3.8	1.9
- sacks (depreciated over 2 seasons)	15	0.63	4.7
- basket (depreciated over 2 seasons)	5	0.8	2.0
Sub-Total (D)			10.1
E. TOTAL (A+B+C+D)			234.6
F. Contigency (5% of E)			11.7
G. TOTAL (E+F)			246.4
H. Interest :			
- Bank rate, 25% p.a			61.6
GRAND TOTAL			307.9
REVENUE			
Yield / acre (mt)			8.0
Price (cedis)/ unit of produce…			80.0
Gross Revenue			640.0
Net Revenue			332.1
Return on Investment, %			107.8

Source: Compiled from PPMD and SRID(MoFA) Various Issues

Appendix VIII: AVEREAGE YEILD OF CASSAVA ON REGIONAL BASIS IN GHANA(Figures in MT/HA): 1997 2005

Region	WESTERN	CENTRAL	EASTERN	GT. ACCRA	VOLTA	ASHANTI	BRONG-AHAFO	NORTHERN	U.WEST	U.EAST
1997	9.5	11.0	11.5	7.3	17.5	10.1	15.1	7.0		
1998	9.3	9.7	12.0	6.0	17.7	10.0	12.0	6.5		
1999	9.7	13.0	12.5	6.0	17.7	11.6	11.0	6.8		
2000	9.6	17.6	11.5	5.9	16.9	9.8	13.5	6.5		
2001	9.8	18.3	11.6	6.2	15.5	10.1	14.1	7.3	-	-
2002	10.7	14.5	12.0	6.7	17.2	10.5	14.6	8.3	-	-
2003	10.7	14.5	12.0	6.7	17.2	10.8	14.6	8.3	-	-
2004	11.2	14.5	12.0	7.0	14.0	10.2	14.5	8.4	-	-
2005	11.1	12.5	18.4	7.6	13.7	11.0	19.4	11.7	-	-
Average	10.2	14.0	12.6	6.6	16.4	10.5	14.3	7.9		

Source: Compiled from PPMD and SRID(MoFA) Various Issues

Appendix IX: Optimal Expenditure Levels for Major Activities Separating zones

FOREST ZONE								
CCP_i	$\|CCP_i\|$	$\frac{1}{CA_i} = \frac{\|CCP_i\|}{\|CCP\|}$	β_i	$CA_i = \beta_i(1/CA_i)$	% effect of CA_i	Average CA_i (GHC)	Required $CA_i(GHC)$ adjustment	Optimal CA_i (GHC)
CCP	0.051		0.145	0.145	14.5	43.03	6.24	49.27
CLP	-0.002	-0.047	0.757	-0.036	-3.6	92.79	-3.34	89.45
CP	-0.042	-0.824	0.177	-0.146	-14.6	58.25	-8.50	49.75
CFM	0.011	-0.216	0.681	-0.147	-14.7	75.40	-11.08	64.31
CH	-0.013	-0.255	0.556	-0.142	-14.2	93.19	-13.23	79.95
TAC					-11.3	319.62	-36.16	283.46
TCCP					-8.25	362.65	-29.92	332.73
TRANSITION ZONE								
CCP_i	$\|CCP_i\|$	$\frac{1}{CA_i} = \frac{\|CCP_i\|}{\|CCP\|}$	β_i	$CA_i = \beta_i(1/CA_i)$	% effect of CA_i	Average CA_i	Required CA_i adjustment	Optimal CA_i
CCP	0.107		0.141	0.141	14.1	43.54	6.14	37.40
CLP	-0.018	-0.168	0.848	-0.142	-14.2	113.62	-16.13	97.49
CP	-0.046	-0.430	0.329	-0.141	-14.1	69.83	-9.85	59.99
CFM	-0.031	-0.290	0.489	-0.142	-14.2	77.33	-10.98	66.35
CH	-0.019	-0.178	0.781	-0.139	-13.9	127.61	-17.74	109.87
TAC					-14.1	388.40	-54.70	333.70
TCCP					-11.2	431.94	-48.56	383.38

CCP=Cost of cassava production matrix, i=cost of various activities of production, TAC=Total activity cost of production, TCCP=Total cost of cassava production CFM=Cost of farm maintenance CH= Cost of harvesting, CLP= Cost of land preparation CP= Cost of planting

Source: Field survey, 2010.

Appendix X: Optimal Expenditure Levels for Land Preparation Separating zones

FOREST ZONE								
CLP_i	$\|CLP_i\|$	$\frac{1}{LP_i} = \frac{\|CLP_i\|}{\|CLP\|}$	α_i	$CA_i = \alpha_i(1/CLP_i)$	% effect of $LPAC_i$	Average $LPAC_i$	Require $LPAC_i$ adjustment	Optimal $LPAC_i$
CLP	0.034		0.182	0.182	18.2	19.93	3.63	23.55
CLP_1	-0.011	-0.324	0.593	-0.192	-19.2	31.32	-6.01	25.31
CLP_2	-0.041	-1.2	0.153	-0.184	-18.4	26.15	-4.81	21.34
CLP_3	-0.017	-0.5	0.379	-0.190	-19.0	35.33	-6.71	28.61
LPAC					-18.9	92.79	-17.54	75.26
TCLP					-12.3	112.72	-13.91	98.81
TRANSITION ZONE								
CLP_i	$\|CLP_i\|$	$\frac{1}{LP_i} = \frac{\|CLP_i\|}{\|CLP\|}$	α_i	$CA_i = \alpha_i(1/CLP_i)$	% effect of $LPAC_i$	Average $LPAC_i$	Require $LPAC_i$ adjustment	Optimal $LPAC_i$
CLP	0.012		0.186	0.186	18.6	18.59	3.46	22.05
CLP_1	-0.004	-0.333	0.549	-0.183	-18.3	37.92	-6.94	30.98
CLP_2	-0.028	-2.333	0.080	-0.187	-18.7	25.67	-4.80	20.87
CLP_3	-0.008	-0.667	0.278	-0. 185	-18.5	50.03	-9.25	40.77
LPAC					-18.5	113.62	-21.00	92.63
TCLP					-13.3	132.21	-17.54	114.67

CLP=Constant, i=activities under land preparation, LPAC= Land preparation activity cost, TCLP=Total cost of land preparation CLP_1= Cost of land clearing, C LP_2 = Cost of stumping, CLP_3= Cost of ridging

Source: Field survey, 2010

Appendix XI: Optimal Expenditure Levels for Planting Separating zones

CP_i	$\|CP_i\|$	$\frac{1}{P_i} = \frac{\|CP_i\|}{\|CP\|}$	γ_i	$CA_i = \gamma_i(1/P_i)$	% effect of ACP_i	Average ACP_i	Require ACP_i adjustment	Optimal ACP_i
FOREST ZONE								
CP	0.00013		0.198	0.198	19.8	19.93	3.95	23.87
CP_1	-0.00014	-1.08	0.183	-0.198	-19.8	16.20	-3.21	12.99
CP_2	-0.00050	-3.846	0.049	-0.188	-18.8	11.40	-2.14	9.26
CP_3	0.00006	-0.462	0.454	-0.209	-20.9	23.26	-4.86	18.40
CP_4	0.00081	-6.230	0.032	-0.199	-19.9	7.40	-1.47	5.92
ACP					-20.1	58.25	-11.68	46.57
TCP					-9.9	78.18	-7.74	70.44
TRANSITION ZONE								
CP_i	$\|CP_i\|$	$\frac{1}{P_i} = \frac{\|CP_i\|}{\|CP\|}$	γ_i	$CA_i = \gamma_i(1/P_i)$	% effect of ACP_i	Average ACP_i	Require ACP_i adjustment	Optimal ACP_i
CP	0.00008		0.240	0.240	24.0	18.59	4.46	23.05
CP_1	-0.00192	-24	0.010	-0.240	-24.0	22.41	-5.38	17.03
CP_2	-0.00021	-2.625	0.092	-0.242	-24.2	14.07	-3.40	10.66
CP_3	-0.00022	-2.75	0.087	-0.239	-23.9	25.80	-6.17	19.63
ACP					-24.0	62.28	-14.95	47.33
TCP					-12.97	80.87	-10.49	70.38

CP=Constant, i=activities under planting activities ACP=Activity cost of planting TCP=Total cost of planting
CP_1=cost of stem cuttings, CP_2= cost of transporting stem cuttings, CP_3=cost of labour for planting,

Appendix XII: Optimal Expenditure Levels for Farm Maintenance Separating zones

FOREST ZONE								
CFM_i	$\lvert CFM_i \rvert$	$\frac{1}{FM_i} = \frac{\lvert CFM}{\lvert CFM}$	ε_i	$CA_i = \varepsilon_i (1/FM_i)$	% effect of CA_i	Average $ACFM_i$ (GHC)	Require $ACFM_i$ adjustment (GHC)	Optimal $ACFM_i$ (GHC)
CFM	0.006		0.200	0.200	20.0	19.93	3.99	23.91
CFM_1	-0.003	-0.5	0.369	-0.185	-18.5	29.48	-5.45	24.02
CFM_2	-0.003	-0.5	0.374	-0.187	-18.7	38.02	-7.11	30.91
CFM_3	-0.028	-4.667	0.045	-0.210	-21.0	7.90	-1.66	6.24
ACFM					-18.9	75.40	-14.22	61.17
TCFM					-10.7	95.32	-10.24	85.09
TRANSITION								
CFM_i	$\lvert CFM_i \rvert$	$\frac{1}{FM_i} = \frac{\lvert CFM_i \rvert}{\lvert CFM \rvert}$	ε_i	$CA_i = \varepsilon_i (1/FM_i$	% effect of CA_i	Average $ACFM_i$ (GHC)	Require $ACFM_i$ adjustment (GHC)	Optimal $ACFM_i$ (GHC)
CFM	0.153		0.199	0.199	19.9	18.59	3.70	22.29
CFM_1	-0.179	-1.170	0.170	-0.199	-19.9	31.27	-6.22	25.05
CFM_2	-0.034	-0.222	0.902	-0.200	-20.0	38.32	-7.66	30.66
ACFM					-20.0	69.59	-13.89	55.70
TCFM					-11.6	88.18	-10.19	77.99

CFM= Constant, i=activities under farm maintenance, ACFM= Activity cost of farm maintenance, TCFM=Total cost of farm maintenance CFM_1=Cost of weeding CFM_2= Cost of fertilizer CFM_3=cost of labour for fertilizer application

Source: Field survey, 2010

Appendix XIII: Optimal Expenditure Levels for Harvesting and Post-Harvest Activities

FOREST ZONE								
CH_i	$\|CH_i\|$	$\frac{1}{H_i} = \frac{\|CH_i\|}{\|CH\|}$	μ_i	$CA_i = \mu_i(1/H_i)$	% effect of ACH_i	Average ACH_i (GH₵)	Require ACH_i (GH₵) Adjustment	Optimal ACH_i
CH	0.0003		0.182	0.182	18.2	43.03	7.83	50.86
CH_1	-0.0002	-0.667	0.279	-0.186	-18.6	30.24	-5.62	24.61
CH_2	-0.0005	-1.667	0.102	-0.170	-17.0	15.19	-2.58	12.60
CH_3	-0.0022	-7.3	0.025	-0.183	-18.3	12.36	-2.26	10.10
CH_4	-0.0001	-0.333	0.423	-0.141	-14.1	35.40	-4.99	30.41
ACH					-16.59	93.19	-15.46	77.73
TCH					-5.6	136.22	-7.63	128.59

TRANSITION								
CH_i	$\|CH_i\|$	$\frac{1}{H_i} = \frac{\|CH_i\|}{\|CH\|}$	μ_i	$CA_i = \mu_i(1/H_i)$	% effect of ACH_i	Average ACH_i (GHC)	Require ACH_i Adjustment (GHC)	Optimal ACH_i (GHC)
CH	0.00004		0.193	0.193	19.3	43.54	8.40	51.95
CH_1	-0.00017	-4.25	0.051	-0.213	-21.3	35.79	-7.62	28.17
CH_2	-0.00014	-3.5	0.060	-0.210	-21.0	15.46	-3.25	12.22
CH_3	-0.00009	-2.25	0.097	-0.218	-21.8	17.28	-3.77	13.52
CH_4	-0.00006	-1.5	0.152	-0.228	-22.8	59.43	-13.55	45.88
ACH					-22.0	127.97	-28.19	99.78
TCH					-11.5	171.52	-19.79	151.73

Separating zones

CH=Constant, i= Sub-activities under harvesting activities, ACH=Activity cost of harvesting TCH=Total cost of harvesting, CH_1= Cost of labour for uprooting roots, CH_2= Cost of carting produce to roadside, CH_3=Cost of bagging produce, CH_4=Cost of transporting produce, GHC=Ghana cedis

COST MINIMISATION FOR CASSAVA PRODUCTION IN THE TRANSITION AND FOREST AGRO-ECOLOGICAL ZONE

MARCH, 2010

SECTION: 1

1.0 General Information

1.1 questionnaire number	
1.2 Name of famer	
1.3 Date (dd/mm/yy)	
1.4 village or town	
1.5 Region	
1.6Agro-ecological zone	
1.7 Name of Enumerator	

2.0 Demographic characteristics

2.1	2.1	2.2	2.3	2.4	2.5	2.6
Gender Male Female	Age	a. Educational level b. Basic (Primary/JHS/Form 4) c. Secondary d. Tertiary e. No education f. Others(specify)	Years in school	Main occupation a. Farmer b. Trader c. Civil servant d. Student e. Artisan f. Others(specify)	Are you a member of an FBO? a. Yes b. No	Residential Status 1. Native 2.Migrant

3.0 Statistics on crops cultivation by farmer

	Crop	Output per acre	Unit of measurement	Total acreage	Selling price per unit
3.1					
3.2					
3.3					
3.4					
3.5					
3.6					
3.7					
3.8					
3.9					
3.10					

3.11 Do you cultivate cassava as a sole crop or inter-crop? (1) Sole (2) inter-crop

3.12 If inter-crop, what are the crops?...

3.13 Among the crops you cultivate, is cassava your main crop? (1)Yes (2) No

3.14 How many years have you been into farming?

3.15 How many years have you been cultivating cassava?

3.16 What cassava varieties do you grow? (1) Abasafitaa (2) Afisiafi (3) Gblemo (4) Bosomsia (5) Ankra (6)Katawia (7)Others (Specify).

4.0 Finance, extension, and input data

4.1 Do you have contact with extension officers? 1. Yes 2. No

4.2 If yes, how many times during the 2009 crop season?...

Source of funding for activities

4.3 Amount of capital invested in 2009 crop season	4.4 Source	4.5 Amount	4.6 Interest rate	4.7 Duration for payment(if borrowed)
	Financial Institutions			
	Family relatives			
	Self financing			
	NGO			
	Other sources			

4.8 Where do you sell your produce?...

4.9 What is the distance between your farm and the nearest market for your produce in miles?

4.10 What is the planting distance between your cassava plants?

SECTION: 2

5.0 Stages of Production, key inputs and level of application

	Activities	Tick	Technology 1.Manual 2.Mechanised	Key Inputs(s)		
	Land preparation					
5.1	Land clearing					
5.2	Slashing Burning					
5.3	Stumping					

5.4	Ridging					
	Planting					
5.6	Actual Planting of cuttings					
	Farm maintenance					
5.7	Weeding					
5.8	Pest and diseases control					
	Harvesting					
5.9	Harvesting of roots					
5.10	Bagging					
5.11	Transportation					
	Carting					

SECTION: 3

6.0 Cost of land preparation/per acre

	Activities	Cost	Quantity	Unit of measurement
6.1	Land clearing			
6.2	Stumping			
6.3	Ridging			
6.4	Others(Specify)			

7.0 Cost of Planting/per acre

	Activities	Cost	Quantity	Unit of measurement
7.1	Stem cutting			
7.2	Transportation of stem cutting to planting field			
7.3	Actual planting of cutting			
7.4	Sorting of stem cutting			
7.5	Others(specify)			

8.0 Cost of farm maintenance/per acre

	Activities	Cost	Quantity	Unit of measurement
8.1	Manual weeding			
8.2	Labour for weedicide application			
8.3	Hiring of machine for weedicide application			
8.4	Fertilizer for application			
8.5	Labour for fertilizer application			
8.6	Others			

8.7 How many days did it take you to weed one acre?

9.0 Cost of Harvesting/per acre

	Activities	Total cost	Quality	Unit of measurement
9.1	Actual harvesting of roots			
9.2	Carting of produce to roadside			
9.3	Bagging			
9.5	Transporting to market centre			

10 Cost of fixed inputs for farming operations

	Tools/Equipments	Total Cost	Quality	Life Span
10.1	Cutlass			
10.2	Hoe			
10.3	Sack			
10.4	Basket			
10.5	Spraying machine			
10.6	Contingencies			
10.6	Interest Rate			

11. Use of hired and family labour (acre)

11.1 Is labour readily available for your activities? (1) Yes (2) No

	Activities	Hired Labour			Family Labour		
		No. of persons	Hours spent per day	No. of days	No. of persons	Hours spent per day	No. of days
11.2	**Land Preparation**						
a	Land clearing						
b	Slashing and Burning						
c	Stumping						
d	Ridging						
e	Land clearing						
11.3	**Planting**						
	Others(specify)						

a	Sorting of stem cuttings						
b	Actual planting of cuttings						
	Others(specify)						
11.4	**Farm maintenance**						
a	Weeding						
b	Pest and diseases control						
	Others(specify)						
11.5	**Harvesting**						
a	Harvesting of root						
b	Bagging						
c	Transportation						
	Others(specify)						
11.6							

12. Constraints and possibly solutions

	Rank	Constraints	Possible solutions
12.1	1st		
12.2	2nd		
12.3	3rd		
12.4	4th		
12.5	5th		