RESOURCE USE EFFICIENCY IN VEGETABLE PRODUCTION: THE CASE OF SMALLHOLDER FARMERS IN THE KUMASI METROPOLIS.

BY

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THIS THESIS IS SUBMITTEDN TO THE UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS.

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DECLARATION

I, ADAMS ABDULAI, author of this thesis titled ‘Resource use efficiency of Vegetable production: the case of smallholder farmers in the Kumasi Methropolis’do hereby declare that, apart from the references of other peoples work, which has been duly acknowledged, the research work presented in this thesis was done entirely by me at the Department of Agricultural Economics, Agribusiness & Extension, University of Science and Technology, Kumasi from August 2005 to August 2006.

I do further declare that, this work has neither been presented in whole nor in part for any degree at this University or elsewhere.

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DEDICATION

This work is dedicated to all my family and fiends, especially my mother, Awusara Adams whose priceless sacrifice and encouragement has made it possible for me to materialize this dream. God bless us all.

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ABSTRACT

This study attempts to find out the current levels of efficiency of some selected vegetable farmers in the Kumasi metropolis. Both Technical and allocative efficiencies were analysed and compared.Further, the effects of some socio-economic variables on efficiency were estimated and compared. The productivity of land and labour in the production process as well the perception of farmers on waste water use were also analysed.

Technical efficiency estimates were obtained using the Stochastic Efficiency Frontier model whiles the allocative efficiency estimates were obtained using the marginal product approach. Productivity of land and labour were estimated using partial productivity measures, the ratio of output to an individual input or input class. Descriptive statistics were used in determine the perception of farmers on water use.

The study found that inefficiency in the vegetable production system exists. The mean technical efficiency of the pooled sample is 66.67%.Efficiency level varies across all production units ranging from 12.9% to 95.02%. There is no significant difference in technical efficiency estimates between production units at 5% level of significance.

Over 80% of vegetable producers covered by the study do not owe land permanently to undertake any meaningful production. The implication is that, investments made in developing the land is minimal or non-existent, permanent farm structures cannot be erected and the future of the vegetable industry is uncertain though it proof profitable to most farmers.

The allocative efficiency indices for land and labour obtained from the study are 0.4556 and 0.4651 respectively. The implication is that both factors of production are overutilised in the production process. The effect of labour on agricultural output is therefore insignificant. This is consistent with the proposition that the use of labour in the agricultural sector is inefficient.

The productivity of land, labour and water were estimated to be ¢91,525,684 per hectare, ¢72,119 per man days and ¢654,754 per cubic meter respectively. Crop water use efficiency as well as field water use efficiency was also estimated to be 1061.71kg/m^3 and 203.08kg/m^3 respectively.

The study revealed that majority of farmers is aware of the health implications associated with the use of untreated waste water for irrigation. . About 91.5% of farmers hold the view that the quality of water being used for irrigation is good and do not pose any threat to the lives of consumers. Water quality is of little priority concern to farmers. What matters most to them is regular supply of water all year round since most of them do not pay for it.

TABLE OF CONTENT

CHAPTER THREE - METHODOLOGY

CHAPTER FOUR – RESULTS AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMES

ML: Maximum Likelihood

OLS: Ordinary Least Squares

MFC: Marginal Factor Cost

SPF: Stochastic Production frontier

COLS: Corrected Ordinary Least Square

ANOVA: Analysis of Variance

KMA: Kumasi Metropolitan Assembly

IWMI: International Water Management Institute

DEA: Data Envelopment Analysis

iid: Identically and independently distributed

MPP: Marginal Physical Product

MVP: Marginal Value Product

CHAPTER ONE

INTRODUCTION

1.1Background

Agriculture is the main stay of most African countries. Ghana's economy for the instance depends largely on its agricultural production. Over the past decade the share of the domestic agriculture in real aggregate national output averaged about 53% annually, Agriculture contributes the food needs of the country. The share of the domestic output and consumption of maize, sorghum and rice for instance were 61.1, 75.8, and 47.8 percent per annum respectively during the past decade (Haizel, 1994).

It was further observed that, agriculture was by far the chief employer in Ghana, representing 66% of the total labour force, and 80% of the working population depended directly or indirectly on agriculture for their livelihood. The agricultural sector is the largest in terms of contribution to GDP (49%), export (70%), and employment (66%), according to the 1989 figures (Asuming-Brempong, 1991).A distortion of the agricultural sector will therefore have an adverse effect on the entire economy. For instance, Killict (1978) and Bequele (1983) were of the view that the retrogression of the Ghanaian economy in the 1970's was largely attributed to the decline in the agricultural sector during that period.

Vegetables may be described as those plants, which are consumed in relatively small quantities as a side dish with the staple food. The term 'vegetable' can also be used to designate the tender edible shoots, leaves, fruits and roots of plants that are eaten whole or part raw or cooked as a supplement to starchy foods and meets (Williams et al, 1991). Vegetables can be distinguished from field crops by the fact that, vegetables are harvested when the plant is fresh and high in moisture while the fields crops are harvested at the mature stage for their grains seeds, roots fibre etc.In human nutrition, vegetables are an essential protective food containing vitamins and minerals. Any balanced diet should include vegetables and fruits for this reason. The proportion of vegetables required in a balanced diet per capita per meal is of the order of 45% of the total volume of the food. Vegetables supply considerable quantities of vitamins A, B, C, D, E and K.According to Agusiobo (1984) vitamin A maintains health of the respiratory and the eye tissue; vitamin B is essential for development of the nervous system; vitamin C maintains health of blood cells and tissues; vitamin D maintains health of bones and teeth; vitamin E maintains heath of the reproductive system; and vitamin K is essential for blood clotting. Iron, which is particularly plentiful in green vegetables, is part of haemoglobin which is found in the blood. The high fibre content of vegetables is essential to maintain the health of the bowels, and a diet which is low in fruit and vegetables frequently results in constipation.Tindall (1983) observed that the leaves of lettuce and cabbage combined supply 184g water; 2.9g protein, 8g carbohydrates, 1.5mg Iron, 49mg phosphorus, 55mg Ascorbic acid, 1.1mg Niacin, 0.8mg Riboflavin, and 0.2mg Thiamin nutrients per 100g of edible portion.

In Africa, three major classes of vegetables are consumed. These include those that are gathered from the wild such as baobab leaves; those indigenous vegetables which are often gathered but are also cultivated such as amaranthus; and imported vegetable species which are cultivated (Rice et al, 1987). The exotic vegetables under study (Lettuce, cabbage, and carrots) fall under the third category. These vegetables are cultivated in the country and are highly patronized by most people especially the middle and high-income classes in the urban areas.

About 800 million people are engaged in urban and peri- urban agriculture worldwide and contribute about 30% to the worlds food supply (UNDP, 1996). This is increasingly becoming a common expression of most urban areas in developing countries and is seen as an important means of attaining balanced diets and urban food security. In several West African countries, between 50 and 90% of the vegetable consumed are produced within or close to the city (Cofie et al, 2003).

Vegetable and vegetable products especially processed forms imported form an essential part of the food in most African countries. This involves the use of limited hard-earned foreign exchange available. Vegetables are important items in the human diet because they supply nutrients such as vitamins and minerals and the bulk of roughage the body needs and which are often lacking in most traditional staple foods.

In recent times there has been a tremendous interest and increase in vegetable crop production in West Africa. This is because of the urgent need to stop the importation of vegetables and vegetable products to help conserve foreign exchange and feed the increasing number of processing factories while exporting the rest to earn more foreign exchange (Norman, 1992). Vegetables and fruit crops add about add about 3% to the GDP of the economy of Ghana (PPMED, 1991). Even though the contribution to the

GDP is very small, its importance cannot be overlooked because without it a diet is not balanced.

In Ghana, backyards are mainly used to cultivate vegetable crops in the urban peri-urban areas by men while marketing of the produce is predominantly in women domain. It also has significant contributions to livelihoods and food security. According to Danso et al (2003), urban farmers grow 90% of the main vegetables eaten in the city of Kumasi.This is done on virtually every open space more close to water sources of almost all major cities and urban centers in the west African sub-region (Danso et al, 2003).

The efficiency of vegetable production is very crucial in determining the returns on investment. Quite often the introduction of new technology has been used as a standard for distinguishing between a modern system and a traditional system (Schultz, 1964), and for improving the efficiency of the production system. However in the developing world, some new technologies have been barely successful in improving productive efficiency. This has often been blamed on the lack of ability and /or willingness on the part of producers to adjust input levels because of their familiarity with traditional agricultural systems and or the presence of institutional constraints (Ghatak and Ingerset, 1983).

1.2 Problem statement

In Ghana urban agriculture has not received the appropriate public and institutional support despite its significant contributions to urban food security, poverty alleviation, women empowerment and improved human nutrition through the provision of balanced diets. Ghana has a high potential and positive comparative advantage for vegetable production. Considerable evidence suggests that serious bottlenecks exist in the functioning of the production system in Ghana.

Anecdotal evidence and inquiry suggest that, a number of factors are responsible for the low vegetable production at the household level**.** A question then arises as to how efficient farmers are using or combining the available scarce resources at their disposal to produce the maximum desired output.

The food production system in Ghana is largely unorganized and inefficient. Post-harvest problems from the farm to the retail level results in high losses, high costs of foodstuffs, and disincentive and discouragement to producers, marketers and consumers. However urban population growth is fuelling the demand for a timely supply of fresh vegetables and much of this demand is satisfied through peri-urban production (Jansen et al, 1996). The problems are acute for dry season vegetable crops. There has however, been little research to ascertain the exact level of production efficiency and on ways to improve the efficiency of dry season vegetable production in Ghana .In fact there seems to have been no previous attempt to determine the efficiency of vegetable production system in the country through the stochastic frontier approach.

While it is obvious that the vegetable production system in Ghana in not efficient, knowledge about the exact level of inefficiency, land, labour productivity is quite blurred. It is also not clear what the impediments, particularly the extent of their impact to efficient vegetable production are. In order to adopt measures in solving the problem of inefficiency in the vegetable production system, there is the need to obtain more specific evidence as to the magnitude of inefficiency. These are key issues central to this study and whose investigation can be useful for the formulation of policies to strengthen and improve the efficiency of vegetable production system. The research issue therefore can be stated in this manner: Are vegetable farmers in the study area operating at their maximum potential given the available scarce resources at their disposal and other constrains to increase their incomes and meet urban food security?

To this end, the following questions are raised:

1 How is dry season vegetable production carried out in Ghana?

2 What are the impediments to the efficiency of dry season vegetable production system in Ghana?

3 How is land and labour used in the production of vegetables in Ghana?

4 Is there any significant relationship between farmer's Socio-economic characteristics and their resource use efficiency?

5 What are farmers' opinions and perceptions regarding the use of different forms of water including untreated water for irrigation?

6 How sustainable is dry season urban vegetable production in terms of existing resources and alternative options?

1.3 Objectives of the study

The primary objective of the study is to evaluate the efficiency of vegetable production in the Kumasi metropolis. Specifically the study sought to:

1 Estimate the technical efficiency of vegetable farmers in the study area.

2 Estimate the allocative efficiency of each factor of production

3 determine the productivity of land and labour in dry season vegetable production

4 Identify and examine the effects of selected socio-economic characteristics of farmers on their resource use efficiency.

5 Assess farmers' knowledge, attitudes and perceptions regarding the use of untreated water in vegetable production.

6 Suggest policy options that will help promote the efficiency of vegetable production in Ghana.

1.4 Justification of the study

Vegetables are important for both domestic and export markets. Almost all households in Ghana include vegetables in their diets. Nutritionally, vegetables are good sources of vitamins, protein minerals and fiber. For those in the producing areas, vegetable production is a major source of income for farmers.in time past the production of vegetables was largely subsistence, with a major portion of the produce consumed by the farm household. Due to increase in demand for dry season vegetables, however, producers now see vegetable production as a business and produce all year round.

An efficient production system is necessary to ensure increased production. The efficiency of the production system also important since it determines the producer's income, consumers living costs as well as facilitates the allocation of productive resources, among alternative uses. Vegetables are high value crops, which require intensive cultural practices and the financial, and labour inputs involved are therefore greater than those required for most staple crops. From existing literature, research in this direction in Ghana still remains out of the spotlight, even though vegetables occupy a unique position in both domestic and foreign food trade of Ghana.This study seeks to close this gap better understanding of the vegetable production system will help eliminate the seasonally low prices and gluts that characterize producer vegetable markets the farm gate level.

This notwithstanding, vegetable production has received much less sufficient scrutiny and institutional support compared with other crops like rice, maize cassava and cocoa. Creating an efficient production system requires an increase in the awareness of farmers, policy makers and all other market stakeholders concerned with the production and actual marketing of vegetables. In this regard, the study will be vital in providing important insights into the nature of and how efficient is the current production system and how it affects producer's enthusiasm and consumer satisfaction.

In addition, factors responsible for low vegetable production at the household level will be brought to the fore and their effects of output analyzed for policy consideration.

The study will serve as a guide to the government, non-governmental organizations and other stakeholders involved in irrigated vegetable production and marketing. It will enhance decisions to ensure produce safety especially highly contaminated vegetables, and this will help improve health through reduction of water contamination due to use in production. Also, the productivity of land and water in vegetable production will be made known as well as the net benefits associated with the whole production process.

Compared to other classes of food crops, there are few basic studies on vegetables. Among these few, most are oriented towards testing varieties, agronomy and physiology.

This study will therefore be a prima facie in adding to the sparse knowledge that exist on vegetables, particularly efficiency of production.

1.5 Hypotheses of the study

To guide the study in arriving at meaningful results, the following null hypotheses will be tested

1 There is no significant difference in the technical efficiency among the farmers selected

2 There is no significant relationship between farmers' socio-economic characteristics and their resource use efficiency in vegetable production.

1.6 Organization of the study

Chapter two presents review of related literature on vegetable production and topics on efficiency. Chapter three examines the theoretical as well as the empirical specification of models for the estimation of technical and allocative efficiencies.

The results and discussion of technical and allocative efficiency estimates, land and labour productivity estimates, determinants of efficiency, problems of marketing vegetables and farmers' perception regarding the use of untreated water for irrigation are presented in chapter four.Summary, conclusions and policy recommendations of the study are presented in chapter six.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

A tremendous amount of research has been done on agricultural production, which has a bearing on this study. This chapter reviews these studies to obtain facts that will provide the context within which the study can be understood, and help to take a theoretical position to inform the study. The review also provides insights into the theoretical framework that can be applied for the analysis. The areas covered include; the Socio-economic importance of vegetables, the concept of efficiency, Resources in vegetable production, methodological review and efficiency estimation procedures, and causes of inefficiency.

2.1 Socio-economic importance of Vegetables.

Vegetables are known to enrich some diets with nutrients including lipids, carbohydrates and vitamins (Komolafe et al, 1980). Vegetable crops are important for almost every household. According to Dittoh (1992), vegetables add flavor to the food and also provide considerable protein, vitamins and minerals. Most vegetables are low in starch content and are a good source of phytonutrients. They serve as roughage, which promotes digestion, and prevent constipation. Vegetable crops not only improve the nutritional quality of diets, the production of vegetables under irrigation and their marketing provides many people with employment in the dry season

Vegetables constitute a major component of the country's food sector. Though not a staple in most areas of Ghana, the commodity occupies a significant position in the total per capita colorie intake of most Ghanaians .It is estimated that about 70% of the vegetables produced in Ghana is marketed and consumed fresh. (Danso et al, 2003). Like other agricultural commodities, low producer and high consumer prices characterizes vegetable markets a phenomenon that suggests an inefficiency marketing system (Abbot, 1993).

The increasing populations of most tropical countries have led to a new awareness of the importance of vegetable crops as a source of food, accompanied by the realization that many vegetables can supply essential nutritional materials which may not be readily available from other sources (Tindall, 1983).Vegetables play an important role in income generation and subsistence. Recent surveys carried out by the Natural Resources Institute in Cameroon and Uganda provide evidence that vegetables offer a significant opportunity for the poorest people to earn a living, as producers and /or traders, without requiring large capital investments. They are important items for poor households because their prices are relatively affordable when compared to other food items (Schippers, 2000).

Vegetables are important food crops in Ghana. They are produced on a large scale in some parts of the country. Tomato, pepper and garden egg are the most popular vegetables in Ghana (Nkansah et al, 2002).

Dittoh (1992) reported that dry season vegetable production in Nigeria has become a booming business. Apart from the farmer and farm laborers who produce the vegetables, there are many people engaged in moving the produce from the producer to the consumer.

2.1 Concept of Productivity, Economic, Price and technical efficiency

The basic trust of the economics of agricultural production at the micro level is to assist individual farmers or group of farmers to attain their stated objectives through efficient intra farm allocation of resources during a period or over a period of time. Economics of agricultural production is achieved either by maximising output from given resources or minimizing the resources required for producing a given output**.**

Attempt to explain the production behavior of firms have led to the development of specific theoretical models based on varying assumptions concerning the objective function of the firm, the market structure and the environment within which the firm operates. The neoclassical (Profit maximization) model had become very popular among production economist in explaining the behavior of the firm. The model assumes that:

The firm has a single overall objective of profit maximization.

The world operates under condition of perfect knowledge.

These assumptions imply that behaviorally, the firms operates strictly in line with the principle of equi-marginality in their decision making process (Olayide and Heady, 1982). The equi marginal principle of equal marginal returns is the neo-classical economic criterion of efficiency in resource use and allocation in multi product firms such as small holder farms. For a multi product firm to be said to have allocated its resources optimally among its feasible production enterprises, it must do it in such a way that the MVP of every input is equal in all enterprises in which it is employed and also equal to the price of input (Upton, 1973).

Resource productivity is definable in terms of individual resource inputs or a combination of them. Optimal productivity implies an efficient utilization of resources in production process hence productivity and efficiency are synonymous in this content

Besides the production function, other techniques have been used for empirical estimation of resource productivity and efficiency. One of such techniques involves calculating input output ratios. This means that individual resource productivity in any production process is measured in terms of the ratio, which the total enterprise bears to the amount of input used. A much more powerful technique from which MVP of resources is derived is linear programming.

Quit apart from substantial data requirement, which is difficult to generate in a largely traditional agriculture, linear programming has other limitations. First, the MVP derived from the model is specific to the use of resource in the particular situation and this frequently differs significantly from those derived from similar situation in the same environment or from actual market situation. In addition, only binding resources have non-zero MVP in the optimal solution. This does not permit Knowledge of the MVP of resources that have not been exhausted in the production process. Linear programming result cannot be tested statistically to know the degree of reliability (Olayide and Heady, 1982).

Another powerful tool of investigating the resource use efficiency on the farm is the stochastic production frontier. Aigner, et al (1977) and Coelli (1995) have employed it to capture resource use efficiency of farmers. This study will adopt the stochastic production approach.

2.1.1 The Concept of efficiency

The concept of efficiency is at the core of economic theory. The theory of production in economics is concerned with optimization, and optimization implies efficiency (Baumol, 1977). Decision-makers are presumed to be concerned with the maximisation of some measure of achievement such as profit or efficiency. The analysis of efficiency in general, focuses on the possibility of producing a certain level of output at lowest cost or of producing the optimal level of output from given resources. Therefore efficiency measurements that show the scope for improved performance may be useful in the formulation and analysis of agricultural policy (Russell and Young, 1983).

Technical efficiency: Conventionally, the performance of a firm is judged utilizing the concept of economic efficiency, which is made up of two components-technical efficiency and allocative efficiency (Kalarijan and Shand, 1999). According to Vensher (2001) a firm is said to be technically efficient when it produces as much output as possible with a given amount of inputs or produces a given output with the minimum possible quantity of inputs. Similarly, Ellis (1988) defines technical efficiency as the maximum possible level of output attainable from a given set of inputs, given a range of alternative technologies available. According to Koopmans (1951), a production procedure is technically efficient if it cannot increase one output without decreasing another output or increasing at least one input. Debreu (1952) and Farrell (1957) noted that a production unit is efficient as long as it operates on the production frontier, but not necessarily by the Koopmans'definition. If a production unit operated on a part of the production frontier that is parallel to an output axis, it would be able to increase the output associated with the axis without decreasing any other output. Hence, the production unit is not efficient in the Koopmans definition.

Classical text book exposition views a technically efficient firm as producing on the isoquant / production possibility frontier, while a technically inefficient firm operates outside or inside its production possibility frontier (McGuire, 1987).These mainstream definitions have been criticized by Ellis (1988) foe associating Technical efficiency only with input quantities and not with input cost in monetary terms.

Though technical efficiency is as old as neoclassical economics, its measurement is not. Probably this is explained by the fact that neoclassical economics assumes full technical efficiency .Two main reasons justify the measurement of technical efficiency (Kalarijan and Shand, 1999).First a gap exists between realized efficiency and theoretical assumption of full technical efficiency. It has been observed by Bauer (1990) and Kalarijan and Shand (1999) that where technical inefficiency exists, it will exert a negative influence on allocative efficiency with a resultant effect on economic efficiency.

Allocative efficiency (Price efficiency): Farrell (1957) defines allocative efficiency as the ability to choose optimal input levels given factor prices. According to Kalarijan and Shand (1999), the willingness and ability of an economic unit to equate its specific marginal value product is referred to as allocative efficiency. In effect, allocative efficiency refers to the adjustment of inputs and outputs to reflect relative prices (price efficiency) under a given technology (Ellis, 1988).

Unlike technical efficiency concept that only consider the process of production, allocative efficiency concepts pertain to the idea that society is concerned with not only how an output is produced, but also with what outputs and balance of output are produced (Hensher, 2001).

Under conditions of competition in the output markets, production is said to be efficiently organised when the marginal value product (MVP) is equal to the marginal factor cost (MFC) (Doll and Orazem, 1984). A value for the test of production efficiency i.e. the ratio of MVP to the MFC is computed. The ratio of one implies efficient use of a factor.

Since Schultz (1964)'s famous poor but efficient hypothesis, there has been interest in assessing the efficiency of agriculture, especially in developing countries. Olayide and Heady (1982) emphasized resource allocation as a means of achieving maximum efficiency. Maximum efficiency is attained when it becomes impossible to reshuffle resources without decreasing the total value of product of the production. Oladiye and Heady had considered labour and capital to be critical since these are two resources, which can be readapted and moved between parcel of land farms and farming regions. Olayide and Heady had suggested a net profit figure computed on the basis of actual marginal productivity of resources than prices.

However, Akinwunmi (1970) argued that so long as the pricing system accurately reflects the value system and consumer choices, the value productivity of resources could serve as an index of production efficiency.which despite its limitations can be used as a rough tool for analysing aggregate efficiency in agriculture.

Many scholars have attempted to give insights into resource productivity albeit for food crops. In Nigeria, Ogunfowora et al (1975) had determined resource use efficiency in four agricultural division of Kwara State using cross sectional data from some randomly selected farmers. The results showed a case of excessive and inefficient use of labour in traditional agriculture. Equally, Osuji (1978) estimated resource productivity in traditional agriculture in Kano State. The marginal value productivity of seeds was found to be higher than their acquisition cost while those of hired labour were below the average wage rate. The marginal productivity of labour was negative in the three of the five clans showing excessive use of family labour in these areas.

Olagoke (1991) examined the efficiency of resource use in the production system in Anambra State. The study showed statistically significant differences between the net return from irrigated rice field on their swamp rice field and upland rice fields. Alocative efficiency tests revealed that all resources were underutilized.

Onyenwaku (1994) differed from Olagoke comparing resource use efficiency between irrigated and non-irrigated farms. Technical efficiency was found to be higher on irrigated farms than non-irrigated farms. Both farm groups, however, underutilized land, capital and other forms of input but over utilized labour and irrigation services

Ajibefun and Abdulkadri (1990) estimated technical efficiency for food crop farmers under the National Directorate of Employment in Ondo state, Nigeria. Results of analysis indicated wide variation in the level of technical efficiency, ranging between 0.22 and 0.88.

2.1.2 The Concept of Productivity

The production function represents the relationship between outputs of goods and services in real physical (“primal’’) volumes to the different inputs used, also in terms of physical volumes, which can be expressed in terms of output per unit of total input-or productivity (Kendrick, et al, 1981). Productivity can be measured through the use of partial productivity measures, the ratio of output to an individual input or input class or in terms of multifactor productivity (or total factor productivity), the ratio of output to all associated inputs.

Changes in multi-factor productivity are directly equivalent to changes in the economic efficiency of production, in that they reflect improvements in the real cost of production over time (ABSSP, 1979). Measures of partial factor productivity are attractive because they avoid the need for monetary valuation of inputs and for the calculation of constant prices over time (Mahoney, 1980), and can be used to illustrate savings achieved over time (or variations between similar production units) in the use of particular inputs. However, they have the potential to mislead, as they reflect not only improvements in the productive efficiency of the input in question, but also changes in output which resulted from factor substitutions made in response to changes in relative factor prices.

Labour is the major factor of production in the traditional farming systems of West Africa and as such the utilization and productivity of labour is a key element in increasing the agricultural output and incomes of small farmers. To the extent that there is underemployment of labour in Agriculture, the potential exists for increasing output, employment and incomes (Spencer & Byerlee, 1977).

2.2 Factors influencing technical efficiency

Several factors including socio-economic and demographic factors, plot level characteristics, environmental factors and non-physical factors are likely to affect the efficiency of smallholder farmers. Lall (1990) studied many countries in relation to their economic performance. One of his conclusions was that human capital is a crucial element whose importance grows as technology becomes more advanced. In order to compare efficiency in world markets, all industries need skills .The human capital theory (Becker 1994, 1967; Benporah 1967; Mincer 1974) states that an increase in a persons stock of knowledge raises his /her productivity both in the market sector of the economy and in the non-market sector. Sall (2000) calls human capital the ultimate resource and argues that productivity in Sub-Saharan Africa will remain illusive without an improvement in the quality of the work force.

Parikh et al (1995) using stochastic cost frontiers in Pakistani agriculture in a two- stage estimation procedure find that education, number of working animals, credit per acre and number of extension visits significantly increase cost efficiency while large land holding size and subsistence significantly decrease cost efficiency.

Coelli and Battese (1996) in a single estimation approach of the technical inefficiency model for Indian farmers find evidence that the number of years of schooling, land size and age of farmers are positively related to technical inefficiency. Wang et al (1996) using a shadow price profit frontier model to examine the productive efficiency of Chinese agriculture find that household's educational levels, family size and per capita net income are positively related to productive efficiency but off farm employment is negatively related to efficiency.

Tadesse and Krishnamoorthy (1997) find significant differences in technical efficiency across the farm size groups with paddy farms on small and medium sized holdings operate at a higher level of efficiency than large sized farms. They argue that because accessibility to institutional finance depends on asset position particularly land, small farms will be forced to allocate their meager resources more efficiently. Seyoum et al (1998) using the one-stage technical inefficiency model find technical inefficiency to be a decreasing function of education of farmers and hours of extension among farmers participating in the modern technology project while education does not significantly affect the efficiency of farmers using traditional farming methods.

Wadud and White (2000) using stochastic translog production frontier in both one stage and two-stage technical inefficiency model find that inefficiency decrease with farm size and farmers with good soils were significantly more technically efficient. Weir (1999) and Weir and Knight (2000) investigate the impact of education on technical efficiency in Ethiopia and find that household influence the level of technical efficiency in cereal crop farms. Mean technical efficiencies of cereal crop farmers are 0.55 and a unit increase in years of schooling increases technical efficiency by 2.1 percentage points. Nonetheless, one limitation of the Weir (1999) and weir and Knight (2000) is that they only investigate the levels of schooling as the only source of technical efficiency.

Ajibefun and Daramola (1999) have shown that the significant determinants of technical efficiency of block-makers and saw-millers in Nigeria are age of operator, level of education, business experience, and the number of employees and level of investment. Obwona (2000) has shown that the significant determinants of tobacco growers in Uganda are the family size, level of education, health status, hired workforce, and credit accessibility, fragmentation of land and extension workers.

Fane (1975), Khaldi (1975), Huffman (1977), and Stefanou and Saxena (1988) studied the effects of education on allocative efficiency. Fane (1975) and Khaldi (1975) present a positive effect of education on allocative efficiency using U.S. farm data. Huffman (1977) reaches two conclusions on U.S. agricultural production: 1) positive effects of education and extension on allocative efficiency, and 2) substitutability of education and extension in terms of their effects on efficiency. Stefanou and Saxena (1988) demonstrated significant roles of education and experience on allocative efficiency and substitutability of education and experience, using farm-level Pennsylvania diary data.

Owens et al (2001) explore the impact of agricultural extension on farm production and find that access to agricultural extension services raised the value of production by 15 percent in Zimbabwe. Mochebelel and Winter-Nelson (2000) investigate the impact of labour migration on the technical efficiency performance of farms in the rural economy of Lesotho.Using the stochastic production function (translog and Cobb-Douglas), the study finds that households that send migrant labour to south African mines are more efficient than households that do not send migrant labour with mean inefficiencies of 0.36 and 0.24, respectively. In addition, there is no statistical evidence that the size of the farm, the gender of the household head affects the efficiency of farmers. Mochebelel and Winter-Nelson (2000) concluded that remittances facilitate agricultural production, rather than substitute for it. This study does not consider the many other household characteristics that may affect technical efficiency such as education, farmers' experience, and access to credit facilities, and advisory services and the extent to which households that export labour receive remittance.

Russell and Young (1983) applied a deterministic Cobb-Douglas frontier model to a cross-section of 56 farms in England. The results indicate technical efficiencies ranging between 0.42 and 1.0, with a mean technical efficiency of 0.73. Kontos and Young (1983) in their study used deterministic frontier production function to estimate data on 83 Greek farms during the 1980-81 cropping year. The predicted technical efficiencies range between 0.30 and 1.00, with a mean technical efficiency of 0.57.

Kalirajan (1981) applied the stochastic frontier Cobb-Douglas function using data from 70 rice farmers in India. The variance of inefficiency effects was found to be a highly significant component in describing the variability of rice yields.Bagi (1982a) estimated a stochastic frontier Cobb-Douglas production function to determine whether there were any significant differences in the technical efficiencies of crop and mixed enterprise farms in west Tennessee. The variability of inefficiency effects was found to be highly significant and the mean technical efficiency of mixed enterprise farms was smaller than that of crop farms (0.76 and 0.85) respectively.Bagi and Huang (1982a) estimated a translog stochastic frontier production function using same data on the farms considered in Bagi (1982a).The Cobb-Douglas stochastic frontier model was found not to be adequate representation of the data, given the specification of the translog stochastic frontier for both crop and mixed farms. The mean technical efficiencies of crop and mixed farms were estimated to be 0.73, 0.67, respectively.

Battese and Coelli (1988) applied panel data model in the analysis of data for dairy farms in New South Wales and Victoria for three years. The estimated technical efficiencies ranged between 0.55 to 0.93 for New Wales farms and between 0.39 and 0.93 for Victoria farms.Battese et al,(1996) applied the stochastic frontier production function using panel data of wheat farmers in four districts in Pakistan.Thier results show that the technical inefficiency effects are highly significant. The results also indicate that technical efficiency tends to be smaller for older farms and those with greater formal schooling .It was also discovered that the levels of wheat production of farmers tend to approach their potential frontier production levels over time, though there was no evidence of technical change. The technical efficiencies were found to vary considerably over time such that the mean technical efficiencies ranged from 57% to 79% in the districts.

2.3 Resources in vegetable production

2.3.1 Land

Chikwaira (1991) noted that land for agriculture could justifiably be viewed as the most important natural asset and the important resource for the enhancement of peasant production. FAO (1997) also mentioned land as the most fundamental productive resource in the rural economy.

According to Afful (1987), raising agricultural productivity involves making investment in the land itself. However, Afful stated that farm operators could not make much investment unless they are sure of the returns of their efforts and expenses they put into improving the land. In most countries, it has not been possible to increase production as land for cultivation is becoming effectively scarce (Chikwaire, 1991). This according to Chinaware is aggravated by the fact that most lands have lost their productive capacity in a situation where the cost of bringing new lands under cultivation is also high and rising.

Land acquisition and ownership is a hindrance to production. La-Anyane (1969) noted that the specific feature of Ghana's land tenure system, which has served as a barrier to improvement in agriculture, is the fragmentation of holdings. Because of the system of inheritance, many people share a single piece of land so that there is continuous fragmentation of holdings and when there is fragmentation, one important effect is that it discourages economics of scale (Afful, 1987).

According to Chikwaira (1991), where agriculture is the predominant occupation, the means of livelihood will be dependent not only on the fertility and the ease of putting land into productive use but also on the allocation of rights in land and the marketing and sharing of its produce. FAO (1988) also stated that the use of land varies not only according to ecological or physical factors-which may limit what can be grown- but also according to the tenurial arrangements.

Land acquisition for vegetable production in Ghana, under traditional systems where vegetables are grown intercropped with other crops is usually not a problem for farmers (Nurah, 1999). However, he noted that the growth in commercial vegetable production has however been accompanied by a growth in more commercial arrangement for renting land especially for the dry season.

2.3.2 Labour

Apart from land, labour and capital are other essential resources that are of great importance in vegetable production. Land cannot be productive without labour and capital. About three – quarters of households in the country are classified as agricultural households. The proportion reaches about 90% in the savanna zones, 86% in the forest zone and 51% in the coastal savanna zone (Ghana Statistical Service, 1989a).

In his studies on vegetable production in Ghana, Nurah (1999) reported that commercial vegetable production is quite labour demanding and that many farmers will rely on family labour if the farm size is small and production will usually compete with the food and tree crops for family labour. Most farmers therefore hire labour to supplement their own family labour supply.

With regards to urban and peri-urban agriculture, Richter et al (1994) report that some practitioners of peri-urban vegetable production still complain about shortage of labour and it is often found that available family and hired labour has been diverted to higher paid factory employment.

2.3.3 Capital

Vegetable production according to Nurah (1991) is capital intensive; equipment is needed to till the land, to irrigate the crops, to apply crop protection chemicals and to process the harvested products. Asante-Kwatia (2004) mentioned the varied sources of acquiring capital for farming as savings, gifts and inheritance, outside equity capital, leasing, contract production and borrowing.

Richter et al (1994) stated that lack of cash and credit opportunities limit the possibility to substitute inputs (e.g. herbicides for labour intensive tasks). Lack of long term low interest credit is a major constrain to vegetable production, more so for specialized vegetable farmers than for those producing rice (Jansen et al, 1994).

2.3.4 Water

Irrigation has been used to increase production levels in many nations and is used for the production of a whole range of crops including vegetables. Increased crop production depends largely on rainfall reliability. However, rainfall patterns in Ghana are erratic in distribution, which affects crop production directly.

Irrigation has been defined as the application of water supplementary to that supplied by precipitation for production of crops. This broad definition covers a wide range of conditions which include sophisticated formal irrigation schemes with extensive permanent infrastructural facilities as well as traditional recession practices under limited water control schemes (FAO, 1986).

The use of wastewater in agriculture is growing due to water scarcity, population growth, and urbanization which all lead to the generation of yet more wastewater in urban areas. With the increasingly scarcity of fresh water resources that are available to agriculture, the use of urban wastewater in agriculture will increase, especially in arid and semi- arid countries (Wim Van der Hoek, 2004).The major challenge is to optimize the benefits of wastewater as a resource of both the water and the nutrients it contains, and to minimize the negative impacts of its use on human health. Though international guidelines for use and quality standards of wastewater exists (Mara and Cairncross, 1989), these standards can only be achieved if wastewater is properly treated.

Worldwide, it is estimated that 18%of cropland is irrigated; producing 40% of the food (Gleick, 2000).A significant proportion of irrigation water is wastewater.Hussain et al (2001) report on estimates that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater. Smith and Nasr (1992) estimated that one-tenth or more of the world's population consumes foods produced on land irrigated with wastewater. A high proportion of the fresh vegetables sold in many cities, particularly in less developed countries are grown in urban and peri-urban areas.Faruqui et al (2004) reported that more than 60% of the vegetables consumed in Dakar city, Senegal, are grown in urban areas using a mixture of groundwater and untreated wastewater.Homsi (2000) estimates that only around 10% of all wastewater in developing countries receives treatment.

Wastewater quality is affected by the volume and types of industrial effluent released into the sewage system or drains, and the degree of dilution with domestic water and natural sources of flow where these exist. Research conducted in urban ,peri-urban and rural areas near Hyderabad city, India, shows that socio-economic characteristics such as caste, class, ethnicity, gender and land tenure influence the type of wastewater-dependent livelihood activities in which each person engages (Buechler and Devi,2002a ; Buechler et al.,2002; Buechler and Devi.,2003b).The type of crops, livestock and fish that farmers can raise are also affected by the quality of wastewater and the characteristics of the natural environment.Buechler (2004) observed that in hot climates with long dry season, high rates of evaporation cause wastewater to be more saline with high total dissolved solids concentration which may restrict the variety of crops that can be cultivated.

The problem of crop contamination raises significant concerns, not only among health directorates but also in the media. In Ghana, irrigated agriculture remains informal without any cross-sectorial support by authorities. And as farmers at most locations have no alternative to polluted water, they continue to use it. According to Keraita et al (2004), farmers in general place lower priority on the possible nutrient value of wastewater than on its value simply as a reliable water source, especially in the dry season. A similar picture has been found with respect to awareness of pathogen contamination. Cornish and

Aidoo (2000) found that only one in four peri-urban farmers would not drink the water he/she used for irrigation. Farmers do not perceive the water-health problem as a major problem. Those who speak freely usually say that they see no harm in the practice.

According to Obuobie (2003), the source of water or its quality is of little concern to farmers. More important to them is its uninterrupted availability and that they do not have to pay for it. The most acutely problems are access to credit, markets and water supply in peri-urban areas (Cornish and Lawrence, 2001), as well as access to land, seed availability, and low farm gate prices in urban agriculture. The general awareness level for environmental and health issues is low (Danso et al, 2002b) or of less importance than other concerns affecting consumers livelihood and health (food security, malaria etc.).

Health concerns are mostly related to water and crop contamination with pathogens from faecal matter. In Ghana, most urban centers have no means of treating wastewater and the sewage networks serves only 4.5% of the total population (Ghana Statistical Service, 2002). Use of waste water in urban and peri-urban agriculture will not only lessen the pressure on water resources but will also increase water productivity through reuse of water and nutrients, which may be otherwise a nuisance to the environment. However, this practice could have adverse effects on public health and the environment.

Wastewater is a resource of growing global importance and its use in agriculture must be carefully managed in other to preserve the substantial benefits while minimizing the serious risks. Irrigation with untreated wastewater can represent a major threat to public health (of both humans and livestock), food safety, and environmental quality.

2.3.5 Poultry manure

Poultry manure is recognized as being good for tree crops, both on the farm and in the home garden, owing to its slow release properties compared with fertilizer. In such cases.the fresh manure is allowed to decompose for three to six months before use. However, Harris et al (1997) reported that its use on vegetable production is not popular. Those farmers who had experimented with poultry manure on vegetable complain that the manure did not release its nutrients within the three months growing season of the crop, decreasing yields.In addition,it encourage soil pest and disease and increase post harvest losses as the vegetables become more prone to decaying (Harris et al,1997).The labour required and time taken to collect the manure and carry it to the farm is also seen as a major constrain.Poultry manure is also considered dirty and smelly,requiring protective clothing if used.

In contrast, Lopez –Real (1995b) reported that poultry manure along with organic manure was the main input in Kumasi peri-urban horticulture (village of Mim). The material was reported to be highly regarded and by some growers seen to be better than the application of NPK.The use of manure in vegetable production around Kumasi is reported to be increasing (Blake et al, 1997). Quansah (1997) reported that the current use of poultry manure in Atwima District is for vegetable production and a few food crops. Access to poultry manure is reported not to be a problem. Farmers are able to buy truckloads of manure .The price depends on the distance.

2.4 Marketing of Vegetables

Marketing is the process whereby in order to fulfill its objectives, an organization accurately identifies and meets its customers' wants and needs (Ritson, 1986).

Abbot et al (1984) observed that in Coastal West Africa, women handle over 60-90% of domestic farm produce from point of origin to consumption. They also indicated from their studies that women pursue marketing activities as their primary means of obtaining cash income for household expenditure. According to Trevallion and Hood (1968) the trading tradition among women folk is long established and will undoubtedly persist.

2.4.1 Factors Affecting Agricultural Marketing

To Johnson (1991), and Kwarteng and Towler (1994), marketing farm products is affected by certain features of farming that together are unique to the industry. These factors include: Seasonally of products, Perishability of products, Inelastic demand, Bulkiness of products, Production hazards, Changes in market demand, large number of small producers, and geographical specialization of production.

The problems of marketing and prices are among the most difficult of the economic problems to solve. An effective marketing system should include additional production from the farm with no change in its cost of production and facilitate the reduction of prices of agricultural products to the consumer. Tarimo (1977) stated that uncertainties in vegetable marking include price fluctuations, high perishability of the produce, theft and fire outbreaks. Theft and quality deterioration were the calamities with the highest frequency of occurrence and traders handle small quantities of vegetables to reduce the risk of quality deterioration and spoilage.

Scranton and Norton (1949) stated that marketing ability of sellers may influence price within limits. The retailer with superior information, sales ability and judgment can ordinarily market a commodity for more money than can unskilled individual. So for the producer or retailer of exotic vegetable to increase his net margin, he must have access to information on the various marketing channels and the demand of these vegetables in the market area. According to Shepherd and Futrell (1969), 73% of the ultimate consumers' price for vegetables is taken by marketing costs and margins.

According to Cramer et al (1994), marketing efficiency is measured by comparing output and input values determined by the consumer valuation of a good and the costs are determined by the values of alternative production capabilities. Therefore markets are efficient when the ratio of the value of output to the value of input throughout the marketing system is maximized.

Marketing of exotic vegetables in Ghana is not exempted from the many problems militating against marketing of agricultural produce in the country. Asante-Kwatia (2004) asserted that there are inadequate and improperly maintained facilities and this leads to inefficient and high cost of marketing farm produce. He mentioned some of the inadequate facilities as transportation and storage facilities, improper handling and packaging and lack of grading. According to IFAP (1986) the lack of adequate marketing facilities constitute the biggest constrain to improve the productivity of farmers in many instances. Farmers are constraint from obtaining essential farm inputs, which are costly in relation to producer prices. Lack of marketing infrastructure and transport facilities also contribute to low returns.

2.4.1.1 Storage and Grading

Bartels (1972) stated that no proper grading is done at the wholesale level of marketing. Each collection of vegetables such as tomatoes is covered with layers of the best pick with inferior grades down. Wholesalers just mixed the products together and such acts worsen the deterioration of vegetables especially tomatoes and okro.Allen (1959) asserts that economies of scale can be achieved by relatively small businesses when grading schemes are promoted and administered.

Anthonio (1968) points out that trading in foodstuffs exhibit a lack of uniform grades and standards; consistent weights and measures are not often used. He emphasized that the absence of grades and standards inhibit efforts to improve the collection, analysis and dissemination of accurate price data. Anthonio concluded that the absence of standardised units of weights and measures constitute a severe handicap to the conduct of marketing.

In Ghana, vegetables do not undergo any effective storage practices to improve their shelf life. Abbot et al (1984) assert that changes in produce of high value such as fruits and vegetables depend largely on temperature. It is necessary to permanently maintain the produce in appropriate conditions of temperature from time of harvest to the time of consumption. Newman (1977) observed that when fresh okro is kept overnight, it shrinks and changes in taste. Retailers select them and throw them away as losses. According to

Kwarteng and Towler (1994) many agricultural products are perishable; some of which deteriorate fast and have to be stored or processed to avoid spoilage. Where farmers can not afford or do not have access to storage or processing facilities, they are usually forced to sell at low prices to avoid losing their products

2.4.1.2 Marketing information

Brein and Stafford (1968) found out that most vegetable sellers rely on private sources for most of their information about the market system and concluded that market information is very inefficient in most developing countries. Adequate information on demand, supply and price conditions is necessary in a form that is easily understood by traders, consumers and farmers if foodstuffs and vegetables are to be distributed efficiently. Supportive educational and training programmes are also needed to make market information services fully effective.

2.4.1.3 Pricing

While it is generally accepted that demand and supply are the principal factors in establishing prices, there are however, other factors which have influence in establishing the price of a particular product. Newman (1977) asserts that the most important factors which influence selling prices were the cost of buying the vegetables wholesale and the expectation of profit. The inter-city transport charges on retail prices were found to be negligible. In contrast, Soranton and Norton (1949) gave monopoly, lack of information and lack of uniformity of product as factors influencing pricing. According to Johnson (1991), where both buyers and sellers operate as small units, none can individually affect price. The smaller a farmer's scale of business and the less sound his financial position, the more he is at the mercy of the market. According to Johnson (1991), where both buyers and sellers operate as small units, none can individually affect price. The smaller a farmer's scale of business and the less sound his financial position, the more he is at the mercy of the market.

2.4.1.4 Demand

To Barker (1989), the utilities or satisfaction provided by different farm products create the demand for them. Consumer demand is continually changing, and this is exacerbated by the traditional viewpoint of farmers that their role is concluded at the farm-gate.

Kwarteng and Towler (1994) maintained that the demand for food products is generally inelastic; meaning once a person's need for food products is satisfied he is not likely to buy more, even if the food prices drop and extra cash is available. Thus in the absence of storage facilities, surplus food tends to spoil during the harvest period as people do not buy significantly more than required.

2.5 Methodological Issues

Several studies have attempted to estimate efficiency of agricultural production (Xu and Jeffrey), 1998; Khem et al, 1999). According to Xu and Jeffrey (1998) empirical studies of production efficiency have employed a variety of modeling approaches including deterministic versus stochastic; parametric versus nonparametric; and programming methods versus statistical methods. On very broad basis, these techniques can be categorized into stochastic frontier production approaches and nonparametric mathematical programming approaches (Khem- et al, 1999).

The estimation of production frontiers has preceded along two general paths: full frontier which force all observations to be on or below the frontier and hence where all deviation from the frontier is attributed to inefficiency; and stochastic frontiers where deviation from the frontier is decomposed into random components reflecting measurement error and statistical noise, and a component reflecting inefficiency. The estimation of full frontier could be through non-parametric approach (Meller, 1976) or a parametric approach where a functional form is imposed on the production function and the elements of the parameter vector describing the abduction function are estimated by programming (Aigner and Chu, 1968) or by statistical techniques (Richmond, 1974; Green, 1980).

A review of the strengths and weaknesses of these approaches has been done by Coelli (1995).The main strengths of the stochastic frontier approaches are that they deal with factors beyond the researcher's control and measurement errors (stochastic noise)and allow for statistical test of hypotheses that pertain to production structure and the degree of inefficiency. The weaknesses of this approach include the need to impose an explicit functional form for the underlying technology and an explicit distributional assumption for the inefficiency term. The main strength of the nonparametric approaches (also called Data envelopment Analysis, DEA) is that they avoid parametric specification of technology and the distributional assumption of the inefficiency term. Weaknesses of the DEA are that it is deterministic and attributes all deviations from the frontier to inefficiencies thereby rendering the model liable to measurement errors or other errors in the data set.

The drawback of these techniques is that, like the Farrel (1957) technique, they are extremely sensitive to outliers; and hence if the outliers reflect measurement errors they will heavily distort the estimated frontier and the efficiency measures derived from it.

The stochastic frontier approach, however, appears more superior because it incorporates the traditional random of regression. In this case the random error, besides, capturing the effects of unimportant left out variables and errors of measurement in the dependent variable, it could also capture the effect of random breakdown on input supply channels not correlated with the error of the regression. What could have appeared as the major advantage of full frontier models over the stochastic model (i.e. the fact that they provided efficiency indexes for each firm) was latter overcomed by (Jondrow et al, 1982). This study will therefore adopt the stochastic frontier model proposed by Jondrow et al, 1982.

2.6 Deterministic Verses Stochastic Specifications

Parametric production frontiers are composed of deterministic frontier model and the stochastic frontier model. Frontier functions have been estimated using either a deterministic or stochastic specification, which are represented, respectively, as:

$Y_i = f(x_i; \beta) - u_i$ i=1,……,n …………….(a)

$Y_i = f(x_i; \beta) - u_i + vi$ i=1……,n ………………(b)

Where i indexes producers; Y_i is greater than zero is an output scalar; x_i is a vector of inputs and an intercept; β is a vector of coefficient estimates; $u_i \sim N(u,\sigma^2_u)$ is a random variable representing technical inefficiency associated with production of firm i ; and $v_i \sim N(0,\sigma^2_u)$ is a stochastic error term. As seen in equation (b), the stochastic frontier specification involves a stochastic error term, v_i, which is added to the deterministic specification in equation (a).

In the stochastic frontier approach, the technical relationship between inputs and outputs of a production process is described by a production function which establishes the maximum level of output attainable from a given vector of input. As a result it is called the production frontier. Production frontier efficiency estimation can be traced back to the seminal work of Farrell (1957). Stochastic production frontier (SPF) as outlined by Aigner, Lovell and Schmidt (1977), Meeusen and Van Den Broeck (1977) and Battese and Corra (1977) rely on the premise that the deviations from the production function are due to statistical noise. Such a stochastic factor cannot be attributed to the process of production and hence should not be embedded in the inefficiency term.

The stochastic frontier specification has been more widely used than the deterministic specification since the former can handle statistical noise, resulting in more accurate specification. A more complete specification is essential for accurate efficiency measures since the estimated frontier is conditional on the functional form. According to Harold et al (1993), modelling production functions following stochastic frontier analysis is in conformity with production theory. One common criticism of the stochastic frontier method is that there is no a priori justification for the selection of any particular distributional form for the technical inefficiency term, u_i.

There are two objectives in stochastic frontier analysis (Kumbhakar and Lovell, 2000). The first is the estimation of a stochastic frontier function serving as a benchmark against which to estimate technical (or allocative) efficiency of producers (Battese and Coelli, 1988; Kumbhakar et al 1989; Green 1990; and Atkinson et al 2001). Its goal is to estimate an efficiency level of each producer. The second objective is the incorporation of exogenous variables that are neither input to the production process nor outputs of it, but which nonetheless affect producer performance with the intent to identify the determinants of efficiency (Pitt and Lee1981; Kalirajan 1981; Battese and Coelli 1995, and Ali and Finn1989). This second objective is much less explored despite its importance.

It is essential to review specific methodologies used by earlier researchers. Both Khem and Xu and Jeffrey (1998) have used a dual stochastic frontier efficiency decomposition model though the Khem et al (1999) went a step further by comparing the stochastic approach to a nonparametric method using the same data set. The common stochastic frontier function used by both studies is given as:

$$Y = f\,(X_a, \beta) + V_i - U_i$$

Where Y is output, X_a is input vector and β the vector of production function parameters. This model can be regarded as a generalization of the standard regression model; the distinguishing feature is the presence of a one-sided error (u_i). The inefficiency effects term (v_i) is usually assumed to be a normally random variable which is distributed independently of U_i with zero mean and variance, $\sigma^2 v$ and u_i a non-negative error typically assumed to be independently and identically distributed across observations. Both writers used the Cob-Douglas functional form, which though less flexible compared to the translog functional form is self dual and has been used in many empirical studies.

Gavian and Ehui (1999) used interspatial measures of factor productivity based on the Divisia index to estimate the relative productive efficiency of alternative land tenure contracts in Ethiopia. This approach has several advantages. Detailed multi-input and multi-output data can be used irrespective of the number of observations over time. There is no degree of freedom problem and it avoids input-output assumptions. However, the method imposes an implicit structure on the aggregate production technology. A major difficulty of this method is the derivation of aggregate output and input demand measures that represent the numerous outputs and inputs involved in the production process Gavian and Ehui (1999)

Other proposed specifications of the U_i include a truncated normal distribution-N (μ,σ^2u) (Stevenson, 1980) and the gamma density (Green, 1980). The normal-gamma model provides a richer and more flexible parameterization of the inefficiency distribution in the stochastic frontier model than either of the canonical forms, normal-half normal and normal-exponential.

However, several attempts to operationalise the normal-gamma model have met with very limited success, as the log likelihood is possessed of a significant degree of complexity. Greene (1990) attempted a direct, but crude maximization procedure which, as documented by Ritter and Simar (1997) was not sufficiently accurate to produce satisfactory estimates. The difficulties of interpreting the latter have led to a greater number of models that use a half-normal or exponential specification. It appears that there is no objective criterion for choosing between the two specifications apart from the judgement of the individual researcher. Nevertheless, Battese and Coelli (1988) suggested that the half normal is the most useful formulation, which we could use

2.7 Empirical studies: Estimation of Efficiency and inefficiency Equations

Estimation methods exist for the estimation of efficiency and inefficiency equations. These are the: maximum likelihood procedure, the corrected ordinary least squares method (COLS) (Jaforulah and Premachendra, 2003), and Zellner's seemingly unrelated regressions (SURE) approach. In stochastic efficiency estimation, the use of OLS results in parameter estimates that are less efficient (especially the intercept) compared to maximum likelihood estimates (Green, 1980).

Since the stochastic frontier model is nonlinear, a nonlinear estimation procedure produces consistent and efficient estimates (Green, 1980). According to Green (1980), while OLS provides best linear unbiased estimates of the slope and the computed standard errors; it provides a downwardly biased estimate of the intercept. Consequently, he suggests that the OLS estimates of the intercept be adjusted by the largest positive OLS residual. This two step procedure is what is called the corrected ordinary least squares (COLS) method.

Estimation of factors that cause inefficiency has generated considerable debate in frontier studies.Accordding to Khem et al (1998) the most popular procedure is to first estimate efficiency scores and regress them against a set of firm specific factors or to use nonparametric or analysis of variance test (ANOVA).Whilst Khaliranjan (1991) and ray (1988) defend this two step procedure,Khumbhakar et al (1991),Battese and Coelli

(1995) challenge this approach by arguing that firm specific factors should be incorporated directly in the estimation of the production frontier because such factors have a direct impact on efficiency. Notwithstanding this criticism, the two step procedure is still quit popular in investigating the relationship between efficiency and firm-specific effects directly into the frontier model are limited to the parametric approach (Khumbhakar et al, 1991; Battese and Coelli, 1995).

Similarly, Reinschncider and Stevenson (1991) suggest the expression of the inefficiency effects as an explicit function of a variable vector and a random perturbation, as well as the estimation of all the parameters in a single stage maximum likelihood procedure. Likewise Bonilla et al (undated) present a model for a stochastic production function, in which the technical inefficiency effects are specified to be a function of some firm specific factors, together with their interactions with the input variables of production frontier.

2.8 Causes of inefficiency

At base, there are two main reasons why firms or individuals might fail to minimize inputs and input costs. One explanation is that they are in fact seeking to minimize costs, but are being prevented from doing so due to institutional constrains(short run cost curves) or by information problems which prevent them from identifying efficient input combinations and proceses.Also, they are simply not trying to minimize costs, for some behavioral or motivational reason (Hensher,2001).

According to Kalirajan (1981), variables such as credit, education, experience, extension contact and family size may affect efficiency. These factors have a negative relationship with technical inefficiency. There are four main conceptual sources of technical and economic efficiency (Hensher, 2001).

- Failing to minimize the physical inputs (that is ,operating within the production possibility frontier
- Failing to use the least cost combination of inputs (that is ,failing to operate at the point of tangency between the isocost curve and the isoquant)
- Operating at the wrong point on the short run average cost curve
- Operating at the wrong point on the long-run average cost.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

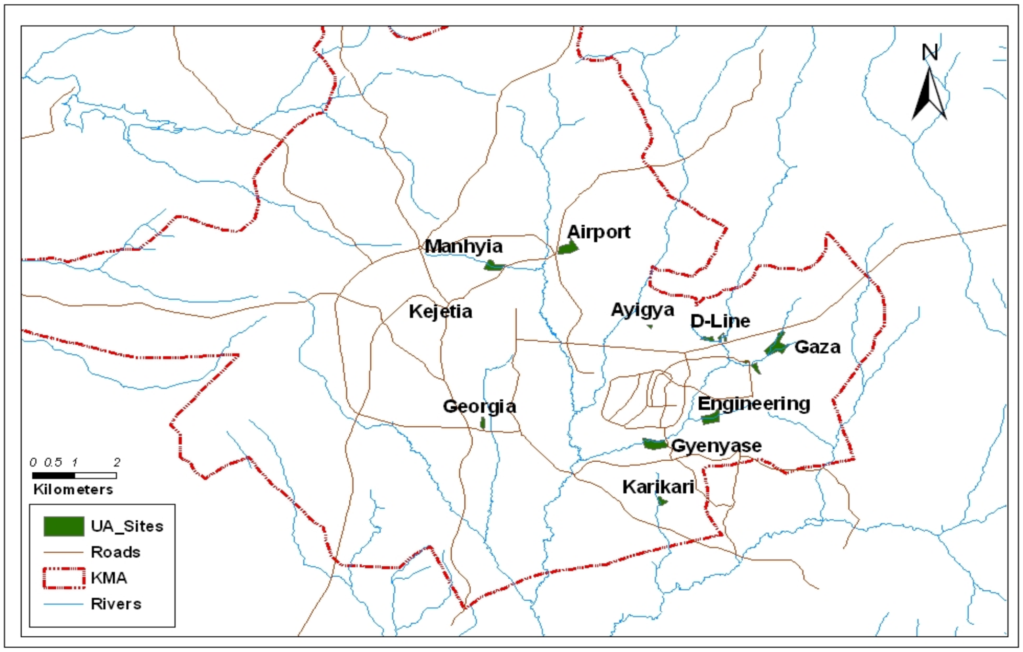
This chapter presents the theoretical foundations as well as the empirical specifications of models used in the stochastic Production frontier in estimating allocative and technical efficiencies of vegetable production. Description of the study area, the method of sample selection and the technique of data collection is also presented in this chapter.

3.1The study area

The study was conducted in nine sites in the Kumasi metropolis where vegetables are mostly grown.Kumasi, the capital of Ashanti region, Ghana has a total population of about 0.98 million inhabitants on an actual area of about 223km^2.It is situated in the forest zone and hence characterized by dense vegetation, bimodal rainfall pattern with a short dry period. The city is endowed with industries / production sectors (such as breweries, sawmills, poultry farms) and important regional markets. The soils are generally rich in Nitrogen, Phosphorus and Organic matter. Majority of the people are small-scale farmers cultivating basically staple crops, legumes and vegetables. The literacy rate is very low. There are also about 1468 registered farmers in the city as well as some 30,000 backyard gardens (KMA, 1996; KNRMP, 1999; MOFA, 1999). The area has a very high agricultural potential. It is based on this reason that the area has been chosen for this study as well as the convenience of obtaining the target group of farmers.

Figure 1 below is a map showing the main vegetable production sites in urban Kumasi that were selected for the study.

Figure 1: Urban Vegetable Production Sites in Kumasi



3.2 Source of data, population and sampling

The source of data was from farmers involved in urban dry season vegetable production in the Kumasi metropolis. The term 'vegetable' as used in this study refers to those exotic leafy vegetables (Lettuce and Cabbage) which are produced all year round and consumed primarily raw as salad crops. Nine vegetable farming sites as identified by IWMI (2005) in the Kumasi metropolis was purposively selected to ensure intensive coverage of the study area. The population for the study comprises all urban vegetable crop producers in the metropolis. List of names of farmers working at the various sites were obtained from vegetable production groups and Fifteen farmers randomly selected from each site to eliminate bias in the sampling process. This gives a sample size of 15 per site and 135-(15*9) in the whole survey.

3.3 Data collection Techniques

The major instrument for collecting the primary data was a semi-structured questionnaire, which was administered to vegetable farmers through personal interviews. Secondary data on existing vegetable production groups and production characteristics of the various sites were also obtained from IWMI office-Kumasi.

Focus group discussions were organized to investigate farmers' knowledge and perceptions regarding the use of untreated water for irrigation, health concerns as well as the various inputs used and to share ideas to enhance production.

3.4 THEORETICAL FRAMEWORK.

3.4.1 Theory of production and Productive efficiency

The economic theory of production provides the analytical framework for most empirical research on productivity and efficiency. Productive efficiency means the attainment of a production goal without a waste. Beginning from this basic idea of ‘‘no waste’’, economists have built up a variety of theories of efficiency. The fundamental idea underlying all efficiency measures, however, is that of the quantity of goods and services per unit of input. Consequently, a production unit is said to be technically inefficient if too little output is being produced from a given bundle of inputs. There are two basic methods of measuring efficiency – the classical approach and the frontier approach. The classical approach is based on the ratio of output to a particular input, and is termed partial productivity measure.

Dissatisfaction with the shortcomings of this approach led economists to develop advanced econometric and linear programming methods for analysing productivity and efficiency. The frontier measure of efficiency implies that efficient firms are those operating on the production frontier. The amount by which a firm lies below its production frontier is regarded as the measure of inefficiency.

3.4.2 Stochastic Production Frontier (SPF) Analysis and measurement of efficiency

The frontier function approach is a method to measure productive inefficiency of individual producers**.** Inefficiency is measured by the deviation from the frontier, which represent a best-practiced technology among all observed firms.

Coelli (1995) presents two reasons to estimate frontier functions, rather than cost functions, which are conventionally estimated by OLS method. First, the frontier function is consistent with theoretical representation of production activities, which is derived from an optimization process. For example, the production function consists of a series of outputs attainable, given different combinations of inputs, while cost and profit functions are represented by frontiers derived from optimization. Second, the estimation of frontier function provides a tool for measuring the efficiency level of each firm within a given sample.

The SPF method of analysing efficiency is chosen for this study. The justification is that, unlike other methods (for example the Data Envelopment Analysis, DEA) the SFP allows for the sensitivity of data to random shocks by including a conventional random error term in the estimation of the production frontier such that only deviation caused by controllable decisions are attributed to inefficiency (Jaforullah and Premachandra, 2003). Inefficiency is assumed to be part of the error term consisting of two parts – a random error term, which is normally distributed N $(0,\sigma^2)$ and represent random shocks and statistical errors, and the inefficiency term which is one-sided (non-negative). The inefficiency error term has a half normal distribution. The SPF is expressed as

$$Y_i = f\,(X_i,\beta)e^{v-u} \qquad (1)$$

In logarithm terms the SPF is expressed as

$$lnY_i = ln\,f\,(X_i,\beta) + V_i - U_i \qquad (2)$$

Where Y_i is the output vector, X_i is the input vector, β is an unknown parameter vector, V_i is the random error term assumed to be iid N $(0, \sigma^2)$, U_i is the inefficiency term independently distributed from V_i.

There is disagreement among econometricians as to the distribution of Ui (Jaforullah and Premachandra, 2003). Previous studies have used several distributions including single parameter half-normal distribution, exponential and truncated normal distributions and two parameter gamma distribution (Jaforullah and Delvin, 1996; Bravo-Ureta and Reiger, 1990; and Sharma et al, 1991). In this study the half normal distribution used by (Jaforullah and Premachandra, 2003) in a cross sectional data similar to this study will be adopted.

For the technical efficiency of firm i at time t, u_{it}, is transformed as $TE_{it} = \exp(-u_i)$, which now represents technical efficiency index. The technical efficiency of the $_i$th firm, defined by $TE_i = \exp(-u_i)$, has a technical inefficiency effect,u_i which is unobservable.Even if the true value of the parameter vector,β,in the stochastic frontier model was known, only the difference,$\varepsilon_i = v_i - u_i$,could be observed.The best predictor for u_i is the conditional expectation given the value of $v_i - u_i$.This result was first recognized and applied in the stochastic frontier model by Jondrow et al (1982),who derived the result as follows:

$$E[u_i / \varepsilon_i] = \frac{\sigma\lambda}{1+\lambda^2}\left[\frac{\phi(z)}{1-\phi(z)} - Z\right] \qquad (3)$$

Where $z = \frac{\varepsilon_i\lambda}{\sigma}$, ϕ is read from the normal distribution table.

An operational predictor of u_i involves replacing the unknown parameters with the ML estimates. Jondrow et al suggested that the technical efficiency of the ith firm should be predicted using $E[u_i/ \varepsilon_i]$. The rationale for this prediction is that $1 - u_i$ is a first order approximation to the equation:

$$\exp(-u_i) = 1 - u_i + u_i^2/2 - u_i^3/6 + \ldots\ldots \qquad (4)$$

After estimating the U_is, firm specific technical efficiency (TE) is then calculated using the formula:

$$TE = \exp(-ui) = e^{-ui} \qquad (5)$$

The SPF requires the specification of a functional form. Most efficiency studies have used the Cobb-Douglas production function on the basis of its simplicity (in terms of analysis and interpretation). But it has been severely criticized for its restrictiveness such as constant elasticity of substitution and fixed returns to scale, the non compliance of which can severely affect the results. Based on this, the use of a more flexible function is imperative. Some studies have employed the translog functional form.The translog function does not establish any restriction beforehand on the elasticity of substitution between inputs, it does not assume homogeneity or seperablity.Furthermore, the flexibility of the translog function minimizes the risk of making errors in the specification.But this functional form has to overcome possible problems of multicollinearity and degrees of freedom. Generally, the translog function is expressed as:

$$\ln Yi = \beta 0 + \Sigma i\beta i \ln Pi + \Sigma j\beta jTj + \frac{1}{2}\Sigma i\Sigma i\beta ii (\ln Pi)^2 + \frac{1}{2}\Sigma j\Sigma j\beta jj (\ln Tj)^2$$
$$+ \Sigma i\Sigma j\beta ij \ln PiTj + Vi - Ui \qquad (6)$$

Where Yi is output, Pi and Ti are inputs of variables, Vi is a random error term, Ui is a measure of inefficiency, βi, βj, βij, βii are unknown parameter estimates.

The above function is assumed to satisfy monotonicity and convexity conditions and such a functional form may be interpreted as an exact functional form or as a functional form close to an unknown function obtained as a Taylor's serial development around an approximation point. According to research conducted by Denny and Fuss (1977) and Alvarez (1994), this study has chosen the appropriate functional form obtained by typifying the variables, that is, by dividing all and each one of the original inputs by their geometric measures which will facilitate the calculation of the elasticities.

Adopting the above to the peculiarities of cross sectional data, the following model is suggested:

$$\text{LnYi} = \ln f(\text{Xi}, \beta) + \text{Vi} - \text{Ui} \qquad (7)$$

Where Yi is the output vector, Xi is the input vector, β is an unknown parameter vector, Vi is the random error term assumed to be iid N $(0,\sigma^2)$, Ui is the inefficiency term independently distributed from Vi and assumes a half-normal distribution.

3.4.3 Analytical Models

For empirical analysis, Cobb-Douglas (1928) stochastic frontier production function will be estimated. It is vital to note that the Cobb-Douglas frontier is the restricted form of the translog frontier, in which the second order terms in the translog function are restricted to be zero.

A Cobb-Douglas production frontier is used to represent the production technology used by vegetable farmers. In defense of this choice, the following can be said. The Cobb-Douglas has been the most commonly used function in the specification of and estimation of production frontiers in empirical studies. It is attractive due to its simplicity and because of the logarithmic nature of the production function that makes econometric estimation of the parameters a very simple matter. It is true as Yin (2000) points out, that this function may be criticized for its restrictive assumptions such as unitary elasticity of substitution and constant returns to scale and input elasticities, but alternatives such as translog production functions also have their own limitations such as being susceptible to multicollinearity and degrees of freedom problems. A study done by Kopp and Smith (1980) suggests that functional specification has only a small impact on measured efficiency. Furthermore, Coelli and Perelman (1999) points out that if an industry is not characterized by perfectly competitive producers, then the use of a Cobb-Douglas functional form is justifiedddd.Considering the fact that the vegetable production industry in Kumasi is not perfectly competitive, the use of this functional form is justified.

3.4.3 Empirical estimation of Technical efficiency

For our imperical analysis, the Cobb-Douglas frontier production function specifies the technology of the production process. The variables associated with production are categorized into output (Y) of lettuce and cabbage in kilograms, Labour (Lab) in mandays,Quantity of manure / fertilizer (M/F) used in kilograms, Quantity of pesticides applied in litres,Capital (Cap) used in cedis, and material (Mat) are other inputs measured as the value of other inputs including fertilizers, manure seeds and pesticides. The model is defined as:

$$Y = f\,(\text{Land, lab, Cap, Mat, Pest, M/F}) \qquad (8)$$

The operational Cobb-Douglas stochastic frontier function for lettuce and cabbage production will be expressed as:

$$LnY = \beta_0 + \beta_1 lnLand + \beta_2 lnLab + \beta_3 lnCap + \beta_4 lnMat + \beta_5 lnPest + \beta_6\, lnM/F + Ei \qquad (9)$$

Y is the output, Cap is the value of capital equipments at current cost on the plot, Lab is the number of mandays of both family and hired labour working on the field, Mat is the value of other inputs including fertilizers, manure seeds and pesticides, Ei is the composed error term given as Ei = Vi –Ui, where Vi is the statistical errors and random shocks such as bad weather, errors in measurement, Ui is the error term measuring the level of inefficiency in production. The βs represents parameters of linear terms.

The technical efficiency of an individual firm is defined in terms of the ratio of observed output to the corresponding frontier output, conditional on the levels of input used by the firm. Hence, the technical efficiency of the $_i$th firm is expressed as:

$$TE_i = \ln y_i / \ln y^* = (f(x_i; \beta) \exp(v_i - u_i) / f(x_i; \beta) \exp(v_i) \quad (10)$$

Following Battese and Coelli (1992) the firm specific technical efficiency (TE) can be evaluated using the conditional expectation of Ui on the random Variable Ei.

$$TE = \exp(-Ui) = e^{-ui} \quad (11)$$

Such that, $0 \leq TE \geq 1$

Firm specific technical inefficiency index is then given as

$$(1 - \exp[-Ui]) \quad (12)$$

If U = 0, it means that vegetable production lies on the stochastic frontier and production is technically efficient. If U > 0, it implies vegetable production lies below the frontier and is inefficient. Inefficiency in production could result from the quality and availability of labour and land, the use of capital and materials, and unhealthy interactions between these factors.

The explanatory variables to be included in the model are similar to those used in previous studies of developing country agriculture (Taylor, Drummond and Gomes, 1986; Taylor and Shonkwiler, 1986). A major difference is that we estimate separate production frontiers for two individual crops while most studies rely on estimates of total value product frontiers.

Estimation of equation (9) was accomplished by maximum likelihood estimation (MLE). Following Aigner, Lovell, and Schmidt (1977) in which Vi ~N $(0,\delta v^2)$ and Ui ~|N $(0,\delta u^2)$|, the following log likelihood function could be obtained:

$$\text{Ln X} = \Sigma\, i \ln L i = \Sigma\, i \left[-\ln\delta - \frac{1}{2}\ln\left(\frac{2}{\pi}\right) - \left(\frac{\varepsilon i}{\delta}\right)2 + \ln\theta\left(\frac{-\varepsilon\delta}{\delta}\right) \right] \qquad (13)$$

Where i is the number of observations, $\delta = (\delta^2 + \delta u^2)^{1/2}$, $\lambda = \delta u/\delta v$, $\varepsilon i = vi - ui$ and_θ is the normal distribution of the function.

3.4.4 Socio-economic model

Average level of technical efficiency measured by mode of truncated normal distribution (i.e.μit) has been assumed (Dawson, Lingard and Woodford, 1991; Kumbhakar and Heshmatic, 1995 and Yao and Liu, 1998) to be a function of Socio-economic factors as shown in the relationship below.

$$\mu_{it} = \alpha_0 +.\alpha_1 R_{1it} + \alpha_2 R_{2it} + \alpha_3 R_{3it} + \alpha_4 R_{4it} + \alpha_5 R_{5it} \qquad (14)$$

Where R_1, R_2, R_3, R_4, and R_5 are age of farmer, level of education, farming experience, access to credit and access to off –farm income respectively. These variables are assumed to influence technical efficiency of the farmers. α_0 to α_5 are parameters which will be estimation using OLS.

3.4.5 Empirical estimation of Allocative Efficiency of Vegetable production.

Allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. A production process is said to be allocatively efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio. The requirement for the fulfillment of allocative efficiency is for the marginal physical product (MPP) of all productive resources to be known (Ellis, 1988). The aim of this study is to estimate the allocative efficiencies of labour and Capital since it is these factors that are substituted for in the production process.

From the cobb-Duaglas function presented in equation 8, the factor elasticities of labour and capital ($E_L$and E_K, respectively) are obtained directly from the equation. The estimation process is based on the allocative efficiency rule which states that the slop e of the production function (MPP) should equal the inverse ratio of input price to output price at the point of profit maximization (Ellis, 1988).

$$MPP_i = \frac{w}{Py} \qquad (15)$$

W is the wage rate, Py is the price of output (Lettuce).Cross multiplying yields

$$MP_L . Py = MVP_L = w \qquad (16)$$

$$\frac{MVP_L}{w} = 1 \qquad (17)$$

That is, the marginal value product of the variable input divided by the input price should equal one. This is the allocative efficiency index (Z) for a single input given by

$$Z = \frac{MVP_x}{Py} \quad (18) \text{ for any variable X}$$

Similarly, for capital,

$$Z = \frac{MVP_K}{Py} \quad (19) \text{ k is the unit price of capital.}$$

The marginal products will be calculated as follows:

$$MP_L = \frac{\mu Yi}{\mu Xi} * E_L \quad (20) \text{ of labour}$$

$$MP_L = \frac{\mu Yi}{\mu Xi} * E_k \quad (21) \text{ for Capital}$$

The allocative efficiency ratios are then expressed as

$$Z = MP_L * \frac{Py}{W} \quad (22) \text{ for labour input}$$

$$Z = MP_K * \frac{Py}{W} \quad (23) \text{ for capital input}$$

Where MP_L, MP_K are the marginal products of labour and capital respectively,μYi and μXi are the arithmetic means (logs) of the output and inputs respectively of the production process.

If Z =1, it implies that the input is utilized efficiently

If Z > 1,it implies an underutilization of the factor input

If Z < 1, it implies an over utilization of the factor input.

3.5 Hypothesis Testing

For the frontier model, the null hypothesis that there are no technical inefficiency effects in the model can be conducted by testing the null and the alternative hypothesis $H_o:\gamma = 0$ against $H_1: \gamma > 0$ .The Wald statistic can be used to test the hypothesis. For the Wald test, the ratio of the estimate for γ to its estimated standard error is calculated. If $H_o:\gamma = 0$ is true, this statistic is asymptotically distributed as a standard normal random variable. However, the test must be performed as a one-sided test because γ cannot take negative values. For the fact that the Wald test is handicapped by its poor size properties, Coelli (1995) suggested that the generalized likelihood-ratio test should be performed when ML estimation is involved because this test has the correct size. However, difficulties arise in testing $Ho:\gamma = 0$ because: $\gamma = 0$ lies on the boundary of the parameter space for γ. Coelli (1995) recommended the one-sided generalized likelihood ratio test of size α which says: Reject $H_o:\gamma = 0$ in favor of $H_1: \gamma > 0$ if λ exceeds$\chi^2 2(\alpha)$.The value for a test of size α= 0.05, is 2.706 [table 1of Kodde and Palm, (1986)].

The first hypothesis which specifies that the sample enterprises are technically efficient will be tested using the generalized likelihood ratio test statistic, which is defined by:

$$\lambda = -2 \ln [L (H_o) /L (H_1)] \qquad (24)$$

Where $L (H_o)$ is the value of the likelihood function for the frontier model, in which the parameter restrictions specified by the null hypothesis, H_o, are imposed, and H_1 is the value of the likelihood function for the general frontier model. If the null hypothesis is true, the λ has approximately chi-square (or mixed square) distribution with degrees of freedom equal to the difference between the parameters estimated under H_1 and H_o, respectively. The second hypothesis will be tested using the ratio of the estimated coefficient of the policy variables to the standard error.

3.6 Estimation of stochastic Frontier and Technical Inefficiency functions.

The estimation was carried out in three steps. First, Ordinary least squares (OLS) estimation of the Stochastic Frontier production function yields estimates of β coefficients. All the estimates except the one for the intercept, β_o are biased. Second a grid search finds γ using the OLS estimates of βo and σ^2 which are adjusted according to the corrected Ordinary least squares formula presented in Coelli (1995). The coefficients, δ are set to zero and γ is limited between zero and one and defined as:

$$\gamma = \sigma^2_u / \sigma^2 \qquad (25)$$

The regression is estimated using the values selected in the grid search as starting values in an iterative procedure to obtain the final ML estimates of the coefficients β and δ, together with the variance parameters that are expressed as:

$$\sigma^2 = \sigma^2_v + \sigma^2_u \qquad (26)$$

The ML estimates for the parameters of the Stochastic frontier model and the predicted technical and allocative efficiency estimates were obtained by using the computer Programme, Lindep Version 7.0, in which the variance parameters are expressed in terms of: $\gamma = \sigma^2_u / \sigma^2$ and $\sigma^2 = \sigma^2_v + \sigma^2_u$ Coelli (1996).

3.7 Definition of Variables

It is argued that the productivity of any enterprise depends on labour and capital. Productivity measurement of outputs, therefore, is a means of quantifying the efficiency with which these inputs are utilized in the production processes a measure of the output of a firm, effective inputs will be considered for this study. In this study, environmental and social effects are not considered as having impact on input use since the main concern is to find out the inefficiency in utilizing the labour and other inputs considered in the production process.

3.7.1 List of variables

Output, input and cost variables associated with dry season vegetable production have been identified. Other variables such as age, education etc relate to policy influences that can enhance the efficiency of the firm will be gathered.

3.7.2 Inputs

Land: area devoted to Cabbage and Lettuce production (hacters) per season.

Labour: Sum of family and hired labour measured in man -days, one man-day is equivalent to 8 hours in this study.

Manure / fertilizer: The quantity of manure /fertilizer in kilograms applied per hectare in a season

Insecticides: The volume of insecticides (in Liters) used per hectare in a season

Material: refers to all cash expenses (Variable cost) incurred in producing an output in a season. Material consists of cost of seeds, cost of fertilizer / manure, cost of insecticides, and other service charges. The measuring unit of material is in cedis.

Capital refers to the value of equipments at current cost used in production.

3.7.3 Determinants of efficiency.

R_1 = Age of farmer

R_2 = Level of education of farmer / decision maker

R_3 = years of farming experience (vegetables only)

R_4 = Access to credit during the cropping season

R_5 = access to off-farm income

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents a discussion of the results. Results on the technical and allocative efficiencies of vegetable production are presented and discussed. The results on factors influencing technical efficiency, productivity of land and labour and the problems of marketing vegetables are also presented and discussed. Finally, the perception of farmers on untreated water use are identified and analyzed.

4.1.1: Estimates of the production frontier function

The estimation of the relative efficiency of production units is conducted by assuming the appropriateness of the log-linear Cobb-Douglas case. The specification of the translog function was also tested. The results of the translog function is not reported in this study because it did not have the right signs for the coefficients and almost all the variables included in the model were found not to be significant. Thus, the specification using the translog function to represent the production technology was not appropriate. Results of the Cobb-Douglas gave the best estimates and hence the choice for it.

All the estimations were done using maximum likelihood methods from the statistical programme LINDEP Version 7.0.The goodness of fit of the estimated regression equations evaluated by R^2 for the OLS looks low. The poor R^2 value may be accounted for by the fact that outliers existed. Apart from these outliers, The R^2 value implies that the inputs to the model do statistically explain the model output. In addition, the F-Statistic of 11.33 shows that the relationship between the variables are significant at 1%

level. Tables 1 and 2 show the results of the OLS and maximum likelihood estimates with the computed log likelihood functions for the Cobb-Douglas frontier model.

Table 1: OLS Estimates of Vegetable Production using Cobb-Douglas frontier production Function.

Variables	Parameters	Coefficients	Standard error	t-value
Constant	B_1	4.1947	0.4472	9.379**
In (land)	B_2	0.1373	0.6373	2.155*
In (labour)	B_3	0.3615	0.3400	0.915
Ln (Capital)	B_4	0.3395	0.2787	4.998
In (materials)	B_4	0.1923	0.4537	4.239**
ln (Pesticides)	B_6	0.1109	0.3348	3.316**
ln (Manure/Fert)	B_7	0.1916	0.3374	0.568
F-Statistic		11.33**		
R-squared		0.2586		

**,* means significant at 1% and 5% levels respectively

Estimated OlS results obtained from the study revealed that most of the coefficients are statistically significant at either 1% or 5% level of significance. The poor R^2 obtained from the results is not relevant for this study because that is not the focus and hence could be ignored. Dawson (1987) and Hallam and Machado (1996) noted that the estimates of the production frontier parameters are not the primary interest when the aim is the measurement of efficiency; in this case the overall predictive power of the estimated function is of great importance

Table 2: ML Estimates of pooled sample using the Cobb-Douglas Production frontier function

Variables	Parameters	Coefficients	Standard error	t-value
Constant	B_1	4.6540	0.3374	13.793**
Ln (land)	B_2	0.1068	0.4740	2.254*
Ln (labour)	B_3	0.1678	0.3205	0.052
Ln (Capital)	B_4	0.3452	0.2992	1.154
Ln (materials)	B_5	0.1586	0.3875	4.092**
Ln(Pesticides)	B_6	0.1119	0.3687	3.035**
In (Manure/Fert)	B_7	0.3578	0.3254	1.099
Variance-ratio	γ	0.7851		
Total variance	σ^2	0.1218		
Sigma-squared	$\sigma^2{}_u$	0.0956		
Log likelihood Fn		-0.4204		

**,* means significant at 1% and 5% respectively

From the Cobb-Douglas frontier production function output presented in Table 2, the estimate of the variance ratio (γ) is significant. The value is 0.7851.This implies that about 78.5% of the variation in vegetable output is attributable to technical efficiency differences among production units. The high value of γ suggests that there are differences in technical efficiency among the production units considered in this study. By implication about 21.5% of the variation in output among producers is due to random factors such as unfavorable weather, effect of pest and diseases, errors in data collection and aggregation and the like. The γ parameter is very important because it shows the relative magnitude of the inefficiency variance associated with the frontier model which assumes that there is no room for inefficiency in the model.

4.1.3: Technical Efficiency Estimates

The technical efficiency level of each production unit covered by the study has been computed and the results attached in appendix C.The results indicates a great difference in efficiency levels among production units It is appropriate to question why some producers can achieve relatively high efficiency whilst others are technically less efficient. Variation in The technical efficiency of producers is probably due to differences in managerial decisions and farm characteristics that may affect the ability of the producer to adequately use the existing technology.

The table below shows the distribution efficiency estimates of vegetable producers in the study area using Jondrow et al (1982) conditional expectation predictor.

Table 3: Frequency distribution of Technical Efficiency estimates

Technical Efficiency (%)	No. in Sample	Percentage	Cumulative %
Less than 30	7	5.18	5.18
30 – 40	8	5.92	11.11
41 – 50	7	5.18	16.29
51 – 60	12	8.88	25.18
61 – 70	15	11.11	36.29
71 – 80	67	49.62	85.92
81 – 90	17	12.59	98.51
91 – 100	2	1.48	100
Total	135	100	

The study shows that technical efficiency ranges between 21.9% - 95.02%.The lowest level of efficiency is 21.9% which is far below the efficient frontier by 78.1%.Such production units are technically inefficient. The highest level of efficiency is 95.02% which is only 4.98% away from the frontier. Such production units can be classified as being technically efficient since in reality production units hardly operate at 100% level of efficiency. The mean technical efficiency of the pooled sample is 66.67%.This compares favorably with other efficiency studies conducted in other areas of agriculture. For instance, previous studies in rice had 65% (Kalirajan and Shand, 1986); 75% (Kumbhakar, 1994); 50% (Kalirajan and Flinn, 1983); 59% (Bravo-ureta and Evenson, 1993) and 66% (Pierani and Rizzi, 2002).

The 66.67% mean technical efficiency implies that on the average, 33.33% more output would have been produced with the same level of inputs if producers were to produce on the most efficient frontier following best practices. A greater proportion of the production units (49.6%) are concentrated in the efficiency class of 71 – 80%.The next highest concentration of producers' the efficiency class 81 – 90% which contains 12.59% of the pooled sample.

4.1.4 Hypothesis Testing

The null hypothesis of the study stipulates that there is no technical difference among the sampled vegetable farmers. To test the null hypothesis, the logarithmic likelihood function on the Cobb –Douglas frontier is compared to that of the traditional production function. The frontier function assumes that inefficiency exists among production units of the enterprise. Table 4 presents a summary of the results.

Table 4: Test of hypothesis on technical efficiency

Ho: There is no difference in technical efficiency among the sampled vegetable farmers ($\gamma = 0$)

Log Likelihood function

	Frontier Function	Average Function	λ	Critical value	Decision
Vegetable Production	-0.4205	-23.0540	45.2671	2.706	Reject Ho.

Ho:$\gamma = 0$ lies on the boundary of the parameter space and is difficult to test. For this reason if H_o: $\gamma = 0$ is true, the generalized likelihood ratio statistic, λ,will have a mixture of chi-square distribution as noted by Coelli (1995).The one sided generalized likelihood ratio test of size (α) is; reject H_o: $\gamma = 0$ in favour of H_i: $\gamma > 0$ if γ exceeds χ^2 2(α).Using Table 1 of Kodde and Palm (1986),the value for the test at 5% is 2.706.

Analysis of technical efficiency differences among production units in the enterprise using analysis of variance (ANOVA) test shows that there is no significant difference in the technical efficiency estimates between production units at 5% level of significance. The test results show that the first null hypothesis of technical efficiency for the production units is rejected. Thus inefficiency exists among the production units considered in this study. The ANOVA results show that there are no significant differences in the technical efficiency estimates among the production units at 5% level of significance.

Table 5: Test of significance differences in efficiency between production units.

Source	df	SS	MS	F	F-critical
Regression	1	0.4533	0.4533	0.9429	3.6800
Error	134	64.4165	0.4807		
Total	135	64.4440			

From the results in table 5 above, F calculated is less than the F critical, so we fail to reject the null hypothesis. This means that there are no wide variations in technical efficiency of the sampled production units. The absence of wide variation in the level of efficiency is an indication that little opportunity exists for these production units to raise their level of efficiency.

4.2 Allocative Efficiency estimates

The OLS results presented in table 1 was used alongside with the mean values of the variables included in the model to estimate the allocative efficiencies. From the OLS results, the following mean values were obtained for the variables.

Variable	Mean
Output	6.9077
Land	4.8891
Labour	5.4801
Capital	5.2849
Materials	5.4655
Pesticides	7.7493
Fert/manure	6.7935

The factor elasticities and marginal value products were then computed from the OLS results .For the purpose of illustration, the allocative efficiency of labour is computed as follows.

The OLS estimates and the means of the variable are substituted into equations 18 and 19.From the OLS results; the elasticity of labour input is 0.3615.

Marginal product of labour,

$$MP_L = \frac{\mu Yi}{\mu Xi} * E_L \qquad (20) \quad \text{for labour}$$

$$MP_L = \frac{6.9077}{5.4801} * 0.3615 \qquad = 0.4556$$

$$MP_L . Py = MVP_L = w \qquad (16)$$

$$MVP_L = 0.4556 * 8000 \qquad = 3,645$$

Allocative efficiency index (Z) for a single input given by

$$Z = \frac{MVP_x}{Py} \qquad (19) \text{ for any variable X}$$

$$Z = \frac{3,645}{8,000} \quad = 0.4556$$

All the variables are measured on per season basis. The same procedure as illustrated above was applied to all the other variables. The resulting allocative efficiencies are presented in table 6 .If the allocative efficiency index (Z) is less than unity, it implies the resource is overutilised. If Z is greater than unity, it implies the resource is underutilized and if Z is equal to unity, it implies the resource is efficiently utilized.

Table 6: Allocative efficiency estimates

Variable	MVP	MFC	R= MVP/MFC
Land	30,378	63,725	0.4767
Labour	3,645	8,000	0.4556

From table 6 above, both land and labour are overutilised in the production process. This implies an inefficient utilization of the two factors of production. Labour and land is paid less than their MVP in the production process. This is because the allocative efficiency ratios for both factors are less than unity. This may be due to the fact that almost all the operations on the farm are carried out manually on a fixed piece of land usually smaller in size. Also due to urbanization and scarcity of water resources, farmers are restricted to a particular piece of land, which in most cases do not attract any rent. Thus, shifting cultivation can no longer be practiced resulting in over utilization of the land.

4.3 Determinants of Efficiency

The determinants of efficiency were modeled using socio economic factors that affects farm operations and also has policy implications. The main socio-economic factors which were assumed to have an influence on the productive efficiency of farmers and hence included in the modal include the age of the farmer, availability of off-farm income, access to credit, access to extension services, educational level of farmer and years of experience in the vegetable production industry. These variables were regressed on the inefficiency due to production scores. The results are presented in table 7 below.

Table 7: Determinants of efficiency.

Variable	Parameter	Coefficient	SE	t-Value
Constant	α_1	2.3893	0.7988	2.991
Ext.Contact	α_2	-0.2990	0.1558	-0.192
Age	α_3	-0.5870	0.2344	-2.504**
Off INC	α_4	-0.5870	0.1196	-0.217
Education	α_5	0.3722	0.1228	0.303
Experience	α_6	0.7911	0.1143	0.692
Credit	α_7	-0.2241	0.2686	-0.835

**, Means significant at 1% level.

Access to credit and contact with extension agents during the production season were represented as Dummy variables in the model; 1 being having access to credit or extension and 0 otherwise. From the OLS results presented in table 7 above, Age of farmer; contact with extension agents; access to off-farm income and access to credit all had negative coefficients. The negative coefficients imply negative influence on technical inefficiency. Therefore increasing age would significantly lead to increasing technical inefficiency. The results obtained here follow the apriori expectation. Ageing farmers would be less energetic to work on farms. Hence, they are expected to have low technical efficiency. The negative coefficient of credit means that the use of credit tends to result in declining technical inefficiency. If the production credit obtained by farmers is invested in the farm, it is expected that it would lead to higher levels of technical efficiency since the farmers would be able to purchase high yielding production inputs. Therefore the results obtained follow apriori expectation.

The positive coefficients obtained for level of education, and years of farming experience also follows apriori expectation, given that educational is an important factor in technology adoption. Educated farmers are expected to be receptive to improved farming techniques and therefore should have a higher level of technical efficiency than farmers with less education. The positive coefficient of education is in line with the findings of previous studies by Obwona ,2000; Sidhu and Baanate, 1981; Jamison and Lau, 1982; Pudasaini, 1983) that education has a positive effect on profits, a result that indicates the existence of management related inefficiency (Ali and Byerlee, 1991).

Farming experience having positive coefficient indicates that farming experience would lead to an increase in technical efficiency. This result has also confirmed apriori expectation. More experienced farmers are expected to have higher level of technical efficiency than farmers with low farming experience, given that farming business involves annual routine activity.

Even though from theory access to credit, availability of off-farm income, contact with extension agents and years of production experience are expected to impact significantly on the productive efficiency of farmers, the results obtained from this study is at variance with it. This is explained by the fact that only a small proportion of the respondents had access to these services. Majority of the respondents (59%) did not achieve basic education required to enhance their efficiency. Only 4.44% of the respondents had tertiary education and 36.3% had secondary education (JSS & SSS). Also, only 7.4% of the respondents had access to credit; 15.5%had access to extension services; and 29.6% had access to off-farm income.

The age of the farmer was found to be highly significantly related to productive efficiency at the 1% level of significance. This is explained by the fact that majority of the respondents covered by the study were between the ages of 18 –39 required to boast agricultural production. They are described as being energetic, smart to adopt new technologies and market oriented in production. This therefore enhances their chances of being efficient in the production process. The study revealed that 76.3% of the respondents were between the ages of 18-39years; 20% were between 40 – 49years and only 3.7% was fifty years and above old. This therefore suggests a greater potential to make the vegetable industry more efficient.

Due to the youthful nature of the age structure of the respondents, the number of years that farmers had been in production was very less. Since majority of the respondents were youthful with few years of experience in the vegetable production industry, the study found years of experience in production not to be significantly related to productive efficiency.

4.4 Productivity of land and labour

Partial productivity measures for individual inputs were estimated. The parameters estimated from the field as attached in appendix C is used in calculating the productivity of various factors of production in the production process. The productivity of land is the ratio of gross revenue obtained from production to the land area put under cultivation. The productivity of land was determined for all the nine sites covered by the study. Productivity of land varies from ¢72,386,587/ha to ¢140,325,417/ha. The highest productivity of land is found at Georgia. This could be explained by the fact that it is strategically located closer to the central market site and just behind a popular hotel (Georgia).Because of high demand for lettuce and cabbage at the site, the price of output per unit area is higher than all the other sites. Also the high productivity of land could be attributed to the clean water they use for irrigation. The study revealed that over 80% of the producers were using pipe water for irrigation. The average productivity of land is estimated to be ¢91,525,684 per hectare. This means that if an area of one hectare is put under cultivation for lettuce and cabbage, all things being equal, a revenue of ¢91,525,684 could be realized per season.

The productivity of labour is the ratio of output obtained to the amount of labour input in man days spent on the field. From table 8 below, the productivity of labour obtained from the study varies from ¢52,596.00 to ¢111,776.00 per manday.Labour was found to be more productive at the engineering site than all the other locations. This probably is due to high managerial ability of farmers resulting in better employment of labour in the production process. A greater proportion of farmers at this site were directly responsible for carrying out their farm operations as compared to the other locations where the use of 'farm boys' was prominent. The average productivity of labour is estimated to be ¢72,119 per manday.This imply that if an adult person is made to work on the farm for a production season, all things being equal the potential to generate ¢72,119 exists. The productivity estimates for the various factors are presented in table 8 below.

Table 8: Productivity estimates

Location	Land productivity (¢/ha)	Labour productivity (¢/man-days)	Water productivity (¢/m^3)	Crop water use efficiency (kg/m^3)	Field water use efficiency (kg/m^3)
Genyase	83,472,733	72318.84	639,129	3649.68	182.47
Kotes	97,401,268	52596.68	740,856	3393.38	169.66
Bus.School	75,755,494	70705.12	778,405	5025.95	251.29
Engineering	72,386,587	111776.64	776,993	4498.00	224.90
Kentikrono	86,095,433	55197.36	567,198	4041.73	202.08
Kotei	96,891,049	65417.95	489,482	3485.08	174.25
Eduasi N.S.	107,673,973	74801.32	891,616	6397.95	319.89
Kakari	86,633,663	83665.33	508,499	2598.69	129.92
Georgia	140,325,417	82614.88	683,517	4519.93	225.94
TOTAL	**91,525,684**	**72119.87**	**654,754**	**4061.71**	**203.08**

Water productivity is very essential in any production process most especially in agriculture. Because water is life, it must be used judiciously. The productivity of water is the ratio of the value of output obtained to the volume of water applied during the production process. Water productivity values as revealed by the study ranges from a minimum of ¢891,616 per cubic meter of water used per season. The lowest water productivity figures were recorded at Kotei.This could be explained by the fact that most of their fields were on high grounds and easily dry up. The greatest number of frequency of watering was also seen at the site resulting in a greater water usage in the production process. The average water productivity is found to be ¢654,754 per cubic meter per season.

In order to evaluate as to whether the water applied by farmers is being utilized by the crop efficiently or not, crop water use by plants were estimated. Crop water use efficiency is the ratio of the physical output obtained from the field to the amount of water depleted by the crop in the process of evapotranspiration.The rate of avapotranspiration was assumed to be 5% for this study. The average crop water use efficiency is estimated to be 4061.71kg/m^3.

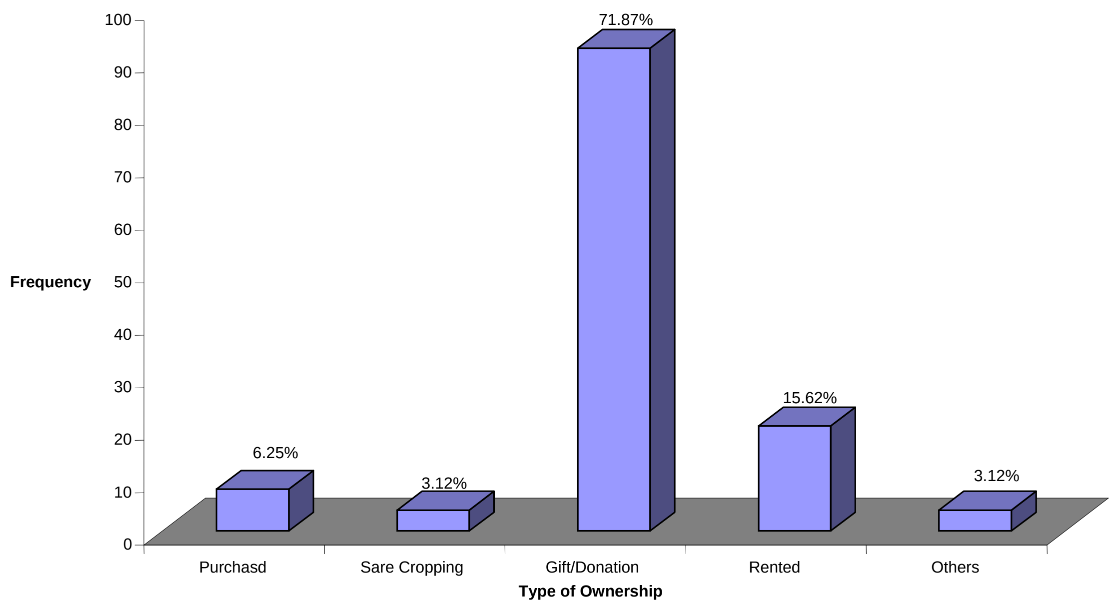
Finally, the field water use efficiency was determined as the ratio of crop yield to the total amount of water applied per hectare. The study revealed that crops grown at the Eduasi New Site were using water more efficiently than crops grown in all other locations covered in the study. This probably could be attributed to soil conditions and the managerial ability of farmers at a site. The average field water use efficiency for the study area is estimated at 203.08kg/m^3.The implication is that, for every one cubic meter of water used in production, a physical output of 203.08kg could be achieved.

4.5 Resources in Vegetable production

4.5.1 Land

Land is a major factor of production and without it no production can take place. The type of ownership of land can affect the efficiency of production. Farmers were asked to indicate how they acquire the ownership of the land used in production .The various forms of ownership of land is summed and presented in figure 2.

F figure 2: Land Tenure /Ownership



From figure 2 above, twenty respondents representing 81.87% acquired their lands through either gift of donations. It was found that majority of the farmers covered by the study were farming on the University of Science and Technology land and are less secured as they could be asked to stop production at any time. Some were also producing on plots either given to them by Chiefs or were caretakers for people studying outside the region or abroad. The implication is that, the development of permanent structures such as wells to ensure all year round production and enhance efficiency in production cannot be achieved. About 3.12% of the respondents were practicing share cropping system. Under this arrangement, land owners are allocated a specified number of beds in every production season. This system is mostly practiced at Kentikrono area. Almost all the farmers who had their lands through this arrangement were migrants from Northern Ghana specifically Upper East Region. One quarter of the number of beds produced per season goes to the land owner while three-quarters is for the farmer.

About 6.25% of the respondents had their lands through purchase. The average amount paid for an area of 10,000m^2 varies from ¢3,000,000 to ¢12,000,000 cedis.Only 3.12% of the respondents hand their lands through inheritance.

In general, over 80% of vegetable producers covered by the study do not owe land permanently to undertake any meaningful production. The implication is that, investments made in developing the land is minimal or non-existent, permanent farm structures cannot be erected and the future of the vegetable industry is uncertain though it proof profitable to most farmers.

4.5.2 Water

4.5.2.1 Sources of water used in Irrigation

The use of untreated water in agriculture is growing due to water scarcity, population growth and urbanization which all lead to the generation of yet more wastewater in urban areas. Farmers in the Kumasi metropolis use a variety of water sources for irrigation. Out of the total number of respondents covered by the study, 9.62% were using the same water source for both drinking and irrigation of vegetables. Majority of the respondents (90.37%) were found not to be using the same water used for irrigation in drinking.

Table 9: Sources of water used in irrigation.

Number	Source	Frequency	Percentage (%)
1	Steam	33	23.9
2	Well	3	2.1
3	Pipe	6	4.3
4	Dugout	96	69.5
Total		138	100

4.5.2.2 Farmers Reasons for not drinking the water used for Irrigation

Farmers expressed varied opinions for not drinking the water they were using for irrigation. From, table 10 below, 66.39% of the respondents said they were not drinking the water because of contamination. The main forms of contamination observed from the field include contamination with feet as farmers enter to fetch the water in streams and dug outs; contamination with feaces as people defecate along streams, and contamination as market women wash the produce directly onto these water sources to make them fresh and remove all debris attached to them. 4.91% of the respondents indicated that the colour of the water was not good as a lot of green materials could be found on the surface of the water. A sample of water source with this characteristic is presented in appendix D.

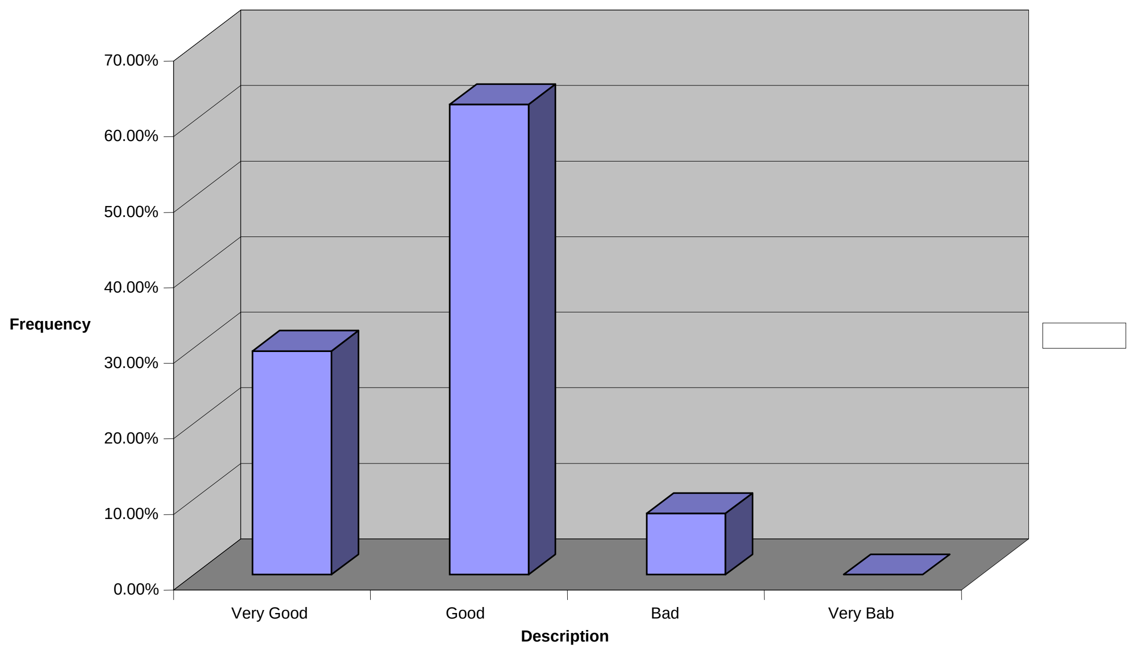
Table 10: Reasons for not drinking the water

Number	Item/Reason	Frequency	Percentage (%)
1	Contamination	81	66.39
2	Availability of pipe water.	15	12.27
3	Colour of water not good/attraction.	6	4.91
4	Presence of organisms in the water.	13	10.65
5	Others (Source of water not known; Dugout reserved for drinking etc).	7	5.73
TOTAL		122	100

4.6 Perception of water use

Figure 3 below shows a summary of farmers' perception of water used for irrigation of vegetables in the Kumasi metropolis. Out of a total of one hundred and thirty five respondents, 29.6%indicated that the quality of the water used for irrigation was very good.62.2% of the respondents say the quality of the water used was good while 8.1% said the quality of the water was bad. Farmers were asked to express their opinion regarding the quality of the water they were using for irrigation. Farmers then made their own judgement. It was found that on the average farmers had a positive perception of the health implications associated with using contaminated / untreated wastewater for irrigation. This could be attributed to the frequent interaction of farmers with other agencies such as IWMI that are working or conducting field experiments with farmers at their level. It was also found that the level of awareness of water safety was high among farmers contributing to their positive perception of health related issues.

Figure 3: Perception of Water Quality



The study revealed that so far no farmer had received any complain from consumers regarding health problems as a result of the water they are using for irrigation. This probably explains why most farmers said that the quality of water used in irrigation is good as shown in figure (3) above. Nineteen (19) out of the one hundred and thirty five (135) farmers covered by the study however admitted that they do suffer some illnesses as a result of using the water for irrigation. The two common sicknesses mentioned are foot rot and fever. Almost all those farmers with such problems were found not having Wallington boots and hence were using their bare foot to enter the water. Generally, farmers are aware of the health implications associated with using contaminated /untreated wastewater for irrigating salad crops like lettuce and cabbage. They do fall sick as applied to all categories of workers but they do not attribute their sickness to the consumption of vegetables produced as a result of the water they are using in production.

4.7 Marketing of Vegetables.

The study revealed that all the farmers covered by the study sell their produce at the farm gate level through market women. Farmers in the study area are therefore restricted to a single channel through which they sell their produce. Hundred percent of the farmers covered were found to be selling their produce through market women. When asked why they could not go to the central market and sell directly to individuals and other organizations, varied responses were given . The main reasons offered by farmers include the intensive nature of their farm operations which may not allow them time to wait and make sales at the market; Creating jobs for others (market women) ; and difficulty in selling the produce at the desired price because of collusive behavior of market women.

4.7.1 Problems of marketing Lettuce and Cabbage.

Table 9 presents the main problems encountered by vegetable farmers in the production process. In most developing countries production is not much of a problem but rather marketing. Farmers were asked to state at least two most pressing problems in order of priority facing them relating to marketing of their produce. The main problems raised is summarized and presented below.

Table 11: Problems of Marketing Vegetables.

Number	Problems	Frequency	Percentage (%)
1	Low/ Unstable prices of produce.	62	32.46
2	Non-reliability of customers.	84	43.97
3	Limited sale outlets	3	1.57
4	Low/No demand for the produce.	34	17.80
5	Lack of storage facilities	4	2.09
6	Lack of financial support.	2	1.05
7	Others (Effects of importation; effect of bird flu on prices etc.)	2	1.05
Total		191	100

From table 9 above, 43.9% of the respondents said the non- reliable nature of their customers is their greatest worry in marketing their produce. Almost all the farmers covered by the study were selling their produce through market women. The non-reliability of customers could be seen in drastic reduction in price levels offered by the market women even when price levels were not so low as alleged by the women; Delay in payment of produce after making a credit purchase; and untimely visits of market women when the produce is in bad condition. This, many of the farmers say is a disincentive to production and does not motivate them to produce more even when the capacity to do so exists. The study revealed that low and unstable prices of produce are a major worry to producers since it is a factor outside their domain. Out of a total of one hundred and ninety one (191) problems raised 32.46% of the responses were centered on price instability due partly to seasonal fluctuations. Most farmers were of the view that government could play a major role in stabilizing prices.

Only 1% of the responses gathered gave attention to lack of storage facilities, lack of financial support and limited sale outlets. This implies that though they were problems in the vegetable production industry, in terms of priority ranking from the viewpoint of farmers, they constitute the least problems facing farmers.17.8% of the responses were on low or no demand for the produce (vegetables) especially during some seasons of the year. To most farmers, the industry was lucrative during the months of March, April and May when the number of producers were fewer due to drying up of most dugouts resulting in higher prices.

The advent of the bird flu disease in poultry was also seen as having a negative impact on the profit levels of vegetable farmers in the metropolis. Farmers said that fast food sellers were the major class of people who demand their produce consistently and in greater quantities. They complained that since the inception of the bird flu disease, most Ghanaians in the metropolis has either stopped or reduced the consumption of fried rice and this they say is having a spillover effect on the demand for lettuce and cabbage produced by them.

CHAPTER FIVE

SUMMARY, CONCLUTIONS, AND RECOMMENDATIONS

5.1 Summary

Efficiencies of the production of vegetables in the Kumasi metropolis have been analysed. The stochastic frontier approach with an inefficiency effects model incorporated has been used for the analysis. The results obtained by the one-stage ML estimation of the model shows that output is irresponsive to changes in labour input. This most likely implies that labour in the agricultural sector is oversupplied and it is not used efficiently. It also has an implication for average earnings rate for farmers. In such circumstances farmers will be paid to work at a very low rate of earnings. As changes for labour input does not have significant effects on agricultural output, government policies directed towards diverting labour into other sectors would not induce an immediate reduction in agricultural output.

Results from the stochastic frontier analysis shows that 78.5% of the variation in vegetable production output is attributable to technical efficiency differences among producers. About 21.5% of the variation in output among producers is due to random shocks such as unfavorable weather, water scarcity, pest and disease attacks and other factors outside the control of producers including errors in data collection and aggregation. The mean technical efficiency of the pooled sample is 66.67%. This high level of efficiency confirms the ‘poor but efficient hypothesis’ propounded by Schultz.

The mean technical efficiency of 66.67% compares favorably with other efficiency studies conducted in other areas of agriculture. For instance, previous studies in rice had

65% (Kalirajan and Shand, 1986); 75% (Kumbhakar, 1994); 50% (Kalirajan and Flinn, 1983); 59% (Bravo-ureta and Evenson, 1993) and 66% (Pierani and Rizzi, 2002

Test for technical efficiency differences among production units shows that there is no significant difference in the technical efficiency estimates between production units at 5% level of significance. The test results show that the first null hypothesis of technical efficiency for the production units is rejected. Thus inefficiency exists among the production units considered in this study. The ANOVA results show that there are no significant differences in the technical efficiency estimates among the production units at 5% level of significance.

The allocative efficiency ratios for land and labour obtained from the study are 0.4556 and 0.4651 reapectively. The implication is that both factors of production are overutilised in the production process.

The main socio-economic factors which were assumed to have an influence on the productive efficiency of farmers and hence included in the modal include the age of the farmer, availability of off-farm income, access to credit, access to extension services, educational level of farmer and years of experience in the vegetable production industry.
Age of farmer; contact with extension agents; access to off-farm income and access to credit all had negative coefficients. The negative coefficients imply negative influence on technical inefficiency. Farming experience and level of education had positive effects on technical efficiency.

The productivity of land, labour and water were estimated to be ¢91,525,684 per hectare, ¢72,119 per man days and ¢654,754 per cubic meter respectively. Crop water use efficiency as well as field water use efficiency was also estimated to be 1061.71kg/m^3 and 203.08kg/m^3 respectively.

The study revealed that majority (81.87%) of vegetable farmers in the Kumasi metropolis are producing on government lands. The implication is that, the development of permanent structures such as wells to ensure all year round production and enhance efficiency in production cannot be achieved.

The non reliable nature of customers is the greatest problem affecting vegetable producers regarding marketing. The non-reliability could be seen in reduction in prices agreed upon by market women, delay in payment of goods and untimely visits when the produce is ready for sale. Problems such as lack of storage facilities, lack of financial support and limited sale outlets were found to be of little concern to farmers in terms of priority ranking of problems that affect the industry.

Generally, farmers are aware of the health implications associated with the use of contaminated water for irrigating salad crops. About 91.8% of the farmers said the quality of water used in irrigation is good and had no health effects on vegetables produced when consumed. The study found that no incidence of ill health arising from the consumption of vegetables produced had been recorded or reported to farmers or market women by consumers. Though farmers admitted that they do fall sick as applied to all categories of workers they do not attribute their sickness to the consumption of vegetables produced as a result of the water they are using in production.

5.2 Conclusions

By estimating a stochastic frontier, for a sample of 135 vegetable producers, the results show that efficiency levels are significantly different across all production units. While some production units were efficient others were not. The uneven distribution of efficiency scores revealed that there are important factors that reduce efficiency which are related to particular production units. Though majority (77.7%) of the production units achieved higher efficiencies, there is stillroom for improvement.

The frontier model used in this study is a static model. The results are the current levels of efficiency of the production units, which could change with time. It was found that there is inefficiency in the production system. This suggests that a significant proportion of the error term in the production is explained by inefficiency effects.

The second stage regression analysis using the determinants of efficiency indicates that most of the variables included in the model were not statistically significant even though they were having the correct signs. Only the age of the farmer was statistically significant at 1% level of significance.

Over 80% of vegetable producers covered by the study do not owe land permanently to undertake any meaningful production. The implication is that, investments made in developing the land is minimal or non-existent, permanent farm structures cannot be erected and the future of the vegetable industry is uncertain though it proof profitable to most farmers.

The allocative efficiency indices for land and labour obtained from the study are 0.4556 and 0.4651 respectively. The implication is that both factors of production are overutilised in the production process. In fact, the effect of labour on agricultural output in general is statistically insignificant. This is consistent with the proposition that the use of labour in the agricultural sector is inefficient.

The productivity of land, labour and water were estimated to be ¢91,525,684 per hectare, ¢72,119 per man days and ¢654,754 per cubic meter respectively. Crop water use efficiency as well as field water use efficiency was also estimated to be 1061.71kg/m^3 and 203.08kg/m^3 respectively.

The non reliable nature of customers is the greatest problem affecting vegetable producers regarding marketing. The non-reliability could be seen in reduction in prices agreed upon by market women, delay in payment of goods and untimely visits when the produce is ready for sale. Problems such as lack of storage facilities, lack of financial support and limited sale outlets were found to be of little concern to farmers in terms of priority ranking of problems that affect the industry.

Generally, farmers are aware of the health implications associated with the use of contaminated water for irrigating salad crops. About 91.5% of farmers hold the view that the quality of water being used for irrigation is good and do not pose any threat to the lives of consumers. Water quality is of little priority concern to farmers. What matters most to them is regular supply of water all year round since most of them do not pay for it.

5.3 Recommendations

The results of the study have some policy implications.

First, the existence of wide variations in the current level of productive efficiency of farmers is a sign that there is ample opportunity for these enterprises to improve upon their operations. Given that a rise in age would lead to a decline in the mean efficiency, government policy should be focused on attracting the youth who are more agile and aggressive to go into vegetable production. The youth employment and job creation programme embarked upon by government could be a platform to accomplish this task. The youth who constitute the majority of the respondents covered in this study has the potential and much-needed effort to help raise the current level of efficiency. More programmes and resources should therefore be channeled through the youth who are engaged in agriculture or are willing to go into agriculture.

Government policies should be aimed at increasing and improving access to credit and extension services to vegetable farmers. A high level of financial support and extension services will not only enhance the acquisition and use of capital equipments needed to enhance farm operations but also facilitate the teaching of new and improved technologies with high level of adoption. This kind of policy may be vital in achieving increased efficiency and productivity of farmers.

Since most resources (land, Labour Manure) are overutilised in the production process less of these factors should be employed by farmers to allow for efficient resource use.

Farmers should play active role in reducing the level of water pollution at the farm level by disallowing market women to wash their produce directly inside the water sources they use for irrigation. Also, practices by farmers themselves such as washing themselves inside steams after pesticide application should be stopped.

To help overcome the numerous problems facing farmers relating to marketing of their produce ,research is needed to investigate how government policy relating to pricing could be designed and effectively implemented for the benefit of producers.

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APPENDIX A

Parameters Estimated from the field

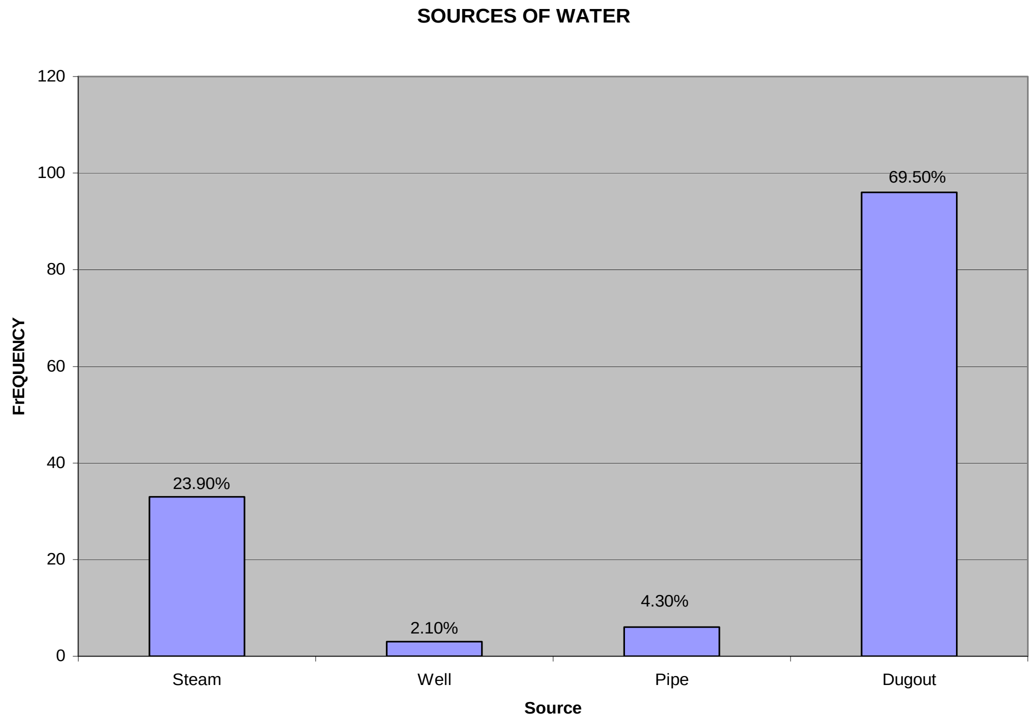
Location	Yield (kg)	Labour (man days)	Volume of water applied (m3)	Land area (ha)	Total Revenue (¢)	EvapoTranspiration (5%)
Genyase	28493.1	1380	156.15	1.195	99,800,000	7.807
Kotes	21802.5	1910	128.5	0.977	95,200,000	6.425
Bus.Sch	35608.9	1560	141.7	1.456	110,300,000	7.085
Engineering	31868.3	985	141.7	1.521	110,100,000	7.085
Kentikrono	29892.6	1520	147.92	0.974	83,900,000	7.396
Ayiduasi	40524.6	1510	126.68	1.049	112,950,000	6.334
Kotei	37611.0	1615	215.84	1.090	105,650,000	10.792
Kakari	26828.9	1255	206.49	1.212	105,000,000	10.324
Georgia	42193.5	1545	186.74	0.909	127,640,000	9.335
Total	294823.66	13180	1451.72	10.385	950,540.000	72.586

APPENDIX B

Technical Efficiency Estimates

0.7895	0.7562	0.3786
0.3325	0.7295	0.6659
0.3706	0.6846	0.7061
0.8139	0.8125	0.8139
0.5616	0.6663	1.0029
0.4535	0.3867	0.4535
0.6715	0.5231	0.7363
0.7623	0.5363	0.7431
0.8128	0.3251	0.5361
0.7294	0.3710	0.5359
0.7660	0.7604	0.7747
0.7924	0.4751	0.7146
0.7923	0.7181	0.7719
0.5026	0.4673	1.0009
0.8204	0.7968	0.2487
0.7652	0.8005	0.7596
0.7689	0.7625	0.8184
0.8155	0.2639	0.7900
0.7065	0.7963	0.7538
0.6615	0.7989	0.5803
0.7335	0.7327	0.6304
0.8092	0.7300	0.7215
0.7925	0.7252	0.7604
0.7333	0.8189	0.7876
0.7256	0.7260	0.7986
0.2852	0.7981	0.8066
0.2339	0.3251	0.7540
0.7744	0.7927	0.7927
0.7097	0.7920	0.7256
0.6661	0.6563	0.6609
0.7922	0.6034	0.7431
0.7263	0.8202	0.7397
0.4779	0.7442	0.7843
0.7655	0.7898	0.7535
0.8178	0.6421	

APPENDIX C



A farmer watering his crops at the Georgia site

Sample of water used for irrigation at the Kentikrono site.

Sample of vegetables grown at the School of Business site KNUST

APPENDIX D

RESOURCE USE EFFICIENCY IN VEGETABLE PRODUCTION

FIELD SURVEY QUESTIONNAIRE

BACKGROUND

1 Date…………… 2 Questionnaire number…………………

3 Name of interviewer…………………………………………………..

4 Name of farmer:……………………………………………………

5 Age of respondent:…………… 6. Sex………………………….

7 Location/ Site:…………………………………………………..

8 Marital Status: Married [1] Single [2] Widowed [3]

9 Farmer's household Size:…………………………………………….

10 Level of respondent's education:

Illiterate /Basic[1] secondary [2] Tertiary [4]

11 Religion: Christianity [1] Islam [2] others [3]…………

12 What is your main occupation?:…………………………………

Agriculture [1] Trading/Commerce [2] Artisan/Carpentry[3]

public Service [4] Others [5] specify…………

13 How much do you earn on the average per month/season?.......................

14 Apart from farming what other work do you do?

Public Service [1] Trading/Commerce[2] Artisan/Carpentry[3]

Agriculture [4] Others [5] Specify…………………………

15 How much do you earn per month/season?..

16 Since when did you start cultivating vegetables?...................................

LAND TENURE

I How did you get the ownership of this farm? Purchase [1] Rented [4] inheritance [2] donation [3] Share Cropping [5] others [5] specify………..

2 If purchased, indicate the Cost of land purchased per season/year……………………

3 If rented, what is the cost ………………… and conditions attached in using the land per season?..

4 What is the total size of your vegetable farm?…………………………

5 What size of the land was used for Lettuce…………… and Cabbage ……….Cultivation this season?

6 Have you increased the area for these two crops this season as compared to last two years? Yes [1] No [0]

7 If yes, by how much area?...................

8 do you think the acquisition of land is a constraint to vegetable production in the area? Yes [1] No [0]

LABOUR

1 Source of labour used: Family [1] Hired labour [2]

2 If family labour is used, indicate the number of people who worked permanently on the field during this season………………

3 How many man-days do you work on the farm per week?................................

4 Complete the table below if hired labour was used.

Farm Operation	No. of people	duration of labor contract	No.of man days	Wage Rate/day	Total Cost
Land clearing					
Bed Preparation					
Nursery work					
Planting					
Weeding/fokinSpraying					
Fert. application					
Watering Harvesting					

ACCESS TO CREDIT

1 Have you used loans during this crop season? Yes [1] No [0]

2 If yes, please fill out this table

Source of loan	Amount borrowed	duration	Interest paid	Use of money borrowed (b)
Friends/relatives				
Money lenders				
Banks				
Market women				
Others				

((b) Used for: 1-buying fertilizer 2-buying pesticides 3-payment of hired labour
4-food expenses 5-health/school fees 6-funerals/dowry
7-purchase of land 8- others…………..

3 If No, how much of your own savings have you invested in the vegetable business this season?..........................

FERTILIZER USE

1 Have you used chemical fertilizers on the vegetables during this crop season? Yes [1] No [0]

2 If yes, please fill out this table

Crop	Quantity of fert.used (kg)	Unit purchasing price (¢/kg)	Total amount spent (cedis)
Lettuce			
cabbage			

3 Have you used manure on the vegetables during this crop season? Yes [1] No [0]

4 If yes, fill out the following table

Crop	Quantity of manure used (kg)	Unit purchasing price (¢/kg)	Total amount spent (cedis)
Lettuce			
cabbage			

SEEDS AND PESTICIDES

1 Fill out this table on seed use

Crop	Type of seed used **((a)**	Quantity of seeds used (kg)	Unit purchasing price (¢/kg)	Total amount spent (¢)
Lettuce				
cabbage				

((a) Seed used: Local seeds [1] Improved seeds [2]

2 Have you used pesticides on your vegetable field during this crop season?
Yes [1] No [0]

3 If yes, please fill out the table below

Insecticides

Crop	Quantity of chemicals used (liters)	Unit purchasing price (¢/liter)	Total amount spent (¢)
Lettuce			
cabbage			
Weedicides			
Lettuce			
Cabbage			

AGRICULTURAL EXTENSION SERVICE

1 Since you started vegetable production, have you ever received any advice from the agricultural extension agents of the Ministry of agriculture on vegetable production practices? Yes [1] No [0]

2 If yes, have you received the visit of agricultural extension agents during this crop season? Yes [1] No [0]

3 If yes, indicate the number of times you have been visited by such agents during this crop season? ………………number of times

AGRICULTURAL EQUIPMENT

1 Please, list all the agricultural tools you own for use in vegetable production in the table below

Type of tool	Number	Date acquired	Purchase price	Life span of tool	Annual depreciation
Sprayer					
Watering Can					
Hoe					
Cutlass					
Fork					
Basket					
Jute bags					
Others a					
B					
C					

WATER USE, KNOWLEDGE AND PERCEPTION

1 What source of water do you use for irrigation? Stream [1] Lake [2] well [3] pipe [4] dugout [5] Others [6] specify………………

2 What would you say about the quality of the water? Very good [1] Good [2] Bad [3] Very bad [4]

3 Do you drink the water you use for irrigation? Yes [1] No [0]

4 If no, why?...

5 Do you experience any health problems in using the water for irrigation?
Yes [1] No [0]

6 If yes, what are they?…………………………………………………………..
....

7 Has any customer ever complained of any health problems after consuming vegetables produced by you? Yes [1] No [0]

8 If yes, what was the problem …………………………………and what was your Response?...

9 Do you pay for the water you use for irrigation? Yes [1] No [0]

10 If yes, how much per month?……………………………………………………

11 If there is an option {pipe water} to the water being used currently, would you be willing to pay some amount for it? Yes [1] No [0]

12 What quantity of water (in Cans) do you usually apply per day on cabbage……………… and lettuce……………….per bed?

13 How often do you water the plants? Once a day [1] Twice a day [2]
Once every two days [3] Once every three days [4] Other [5]……..

OUTPUT AND MARKETING

1 Please indicate the quantities of vegetables harvested this season from your field.

Crop	Quantity harvested(kg) /No. of beds *No of plants
Lettuce	
cabbage	

2 Please fill out the following table on the marketing of agricultural produce

Product sold	No. of beds sold	Unit price Per bed	Total value of sales	Sale outlet **((c)**	Transport costs
Lettuce					
Cabbage					

((c) Sale outlet

Institutions [1] market women [2] individual Consumers [3] others [4] specify………………..

3 Is there any arrangement for the sale of produce at the beginning of the production season? Yes[1] No[0]

4 If yes, what form? Supply of……… Inputs [1] Cash [2] foodstuffs [3] Others [4] specify…………………………………

5 On the average, how much do you earn from the produce per season?………….

6 What major problems do you face in marketing your produce?…………………

……………………………………………………………………………………

THANK YOU FOR YOUR COOPERATION (END OF INTERVIEW)

Date when the Questionnaire was checked……………………………………………………….

Name and signature of supervisor………………………………………………………………….