ALLOCATIVE EFFICIENCY OF IRRIGATED TOMATO PRODUCTION IN THE UPPER EAST REGION, GHANA

BY

FREDERICK Z. PUOZAA

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SCHOOL OF AGRICULTURE
COLLEGE OF BASIC AND APPLIED SCIENCES
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DECLARATION

I, FREDERICK Z. PUOZAA, do hereby declare that this thesis titled "ALLOCATIVE EFFICIENCY OF IRRIGATED TOMATO PRODUCTION IN THE UPPER EAST REGION, GHANA" was carried out by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon from July 2014 to July 2015. The work/materials of other people cited in this thesis have been duly acknowledged. I do further declare that this work has never been presented either in whole or in part for the award of any degree in any institution including the University of Ghana, Legon.

Signature …………………….. ………………………….

Frederick Z. Puozaa Date

(Student)

This study has been submitted for examination with our approval as supervisors.

Signature …………………….. ………………………….

Dr. Henry Anim-Somuah Date

(Major Supervisor)

Signature …………………….. ………………………….

Prof. Wayo Seini Date

(Co-supervisor)

DEDICATION

I dedicate this thesis to my parents, Mr. Lawrence Puozaa and Madam Adriana Mwintuobo and to my uncle Hon. Mathias Asoma Puozaa, who performed an enormous role in educating me.

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I wish to express my profound gratitude to God Almighty, for giving me the wisdom, direction and making this work a success.

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ABSTRACT

Efficiency has been considered as a means of enhancing the productivity of farmers, with most studies on production been geared towards that direction. The inability of farmers to efficiently use available resources has hindered the production of food in Ghana, hence resulting in a deficit in food supply. This study assessed the allocative efficiency of resource use in irrigated tomato production in the Upper East Region. The study was carried out in the key tomato growing districts in the Upper East Region, which are also endowed with well-established public irrigation schemes. These districts include: Kassena Nankana East Municipal, Bongo District and Bolgatanga Municipal. Multistage sampling technique was employed in selecting 80 tomato farmers. Primary data were sourced from tomato farmers through the administration of a semi-structured questionnaire. Data were analysed using descriptive statistics, gross margin analysis, Cobb-Douglas production function and marginal value productivity. Results from the Cobb-Douglas function signify that the variation in yield is explained by the quantity of labour, fertiliser, weedicide, irrigation cost and access to extension service, these variables also showed a positive relationship with yield which is in consonance with a priori expectations. The scale elasticity value of 0.69 is an indication of decreasing returns to scale, thus suggesting that the production is in the rational stage of the production function. The per hectare gross margin analysis showed that, the irrigated tomato production system which does not use water pumps is profitable than the irrigated production system which uses motorised pumps. Farmers who did not use motorised pumps incurred a variable cost of GHS 2,453.68 whereas, the users of motorised pumps incurred GHS 3,022.01. On the average, farmers made a mean revenue of GHS 4,663.54 per hectare of tomatoes produced. The study further revealed that all the productive inputs considered in the study (seed, fertiliser, labour, insecticide, weedicide and irrigation) were not efficiently allocated. Fertiliser and weedicide were underutilised. Seed, labour, insecticide and irrigation were also over utilised. The study thus concludes that irrigated tomato farmers in the Upper East Region are allocatively inefficient. It is recommended that, field demonstration programmes by the Ministry of Food and Agriculture and research institutions such as Council for Scientific and Industrial Research (CSIR) should be strengthened to expose farmers to the practical results of using appropriate quantities of inputs and adhering to good field management practices. The Ministry of Food and Agriculture should also promote agricultural extension education through the various media available in the country to educate farmers on good agronomic practices to enhance productivity through the reduction of the average unit cost of production. Government should also provide financial support for small scale tomato farmers, through programmes like the Ghana Agricultural Sector Investment Programme (GASIP). These support programmes should have an innate policy that mandates beneficiaries to co-finance their production, since this will help to eliminate unserious farmers who might be risk averse and only interested in extorting public funds.

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LIST OF ACRONYMS

BD	Bongo District
CSIR	Council for Scientific and Industrial Research
FAO	Food and Agriculture Organisation
GASIP	Ghana Agricultural Sector Investment Programme
GDP	Gross Domestic product
GIDA	Ghana Irrigation Development Authority
GIHOC	Ghana Industrial Holding Cooperation
GSS	Ghana Statistical Service
ICOUR	Irrigation Company of the Upper Region
KNEM	Kassena Nankana East Municipal
MOFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organisations
SAP	Structural Adjustment Programme
SARI	Savannah Agriculture Research Institute
VIF	Variance Inflation Factor
IFDC	International Fertiliser Development Centre
IFPRI	International Food Policy and Research Institute
ILRI	International Livestock and Research Institute
IFAD	International Fund for Agricultural Development

CHAPTER ONE

INTRODUCTION

1.1 Background

Agriculture forms the driving force of the sub-Saharan Africa economy, thus constituting about one-third of the sub region's (Sub-Sahara Africa) Gross Domestic Product (GDP) (Chauvin, Mulangu & Porto, 2012; World Bank, 2015a). World Bank (2015a) further states that 78% of the world's poor live in rural areas, with majority engaging in agriculture for their livelihoods. This situation is a true picture of Ghana's agricultural sector.

It has been argued by Heisey and Mwangi (1996) that the reliance on food imports to cater for domestic food needs may not be economically feasible by the year 2020. Thus the need for increased domestic production and a justification for Africa's own green revolution (Yawson, Armah, Afrifa, & Dadzie, 2010). In spite of the fact that Ghana is endowed with environmental conditions suitable for the cultivation of a wide range of crops including cereals, legumes, vegetables, fruits, root and tuber crops, the county still meets some of its staple food crop needs through imports. This has been evident in the deficit in the supply of fresh tomato and milled rice in the country (Ghana). For instance, 55.81% of the country's (Ghana) total milled rice needs for the year 2012 were met through importation (MOFA, 2013). FAO (2015c) also noted that 315,221 tonnes of fresh tomatoes were imported into Ghana to supplement domestic supply for the year 2011. The country's inability to cater for its domestic food needs through domestic production, thus suggests that it has consistently been suffering from a series of production and marketing challenges

(Bortey, 2010; Haruna, 2012). This situation thus impedes the success of the tomato industry in the Upper East Region of Ghana. The looming surge in food imports in Ghana coupled with dwindling economic fortunes and worsening climatic conditions, thus tend to suggest that the importation of food items like tomato, rice and poultry might not be economically feasible by the year 2020 as argued by (Heisey & Mwangi, 1996).

Tomato (*Solanum lycopersicum, L.*) is a vegetable crop cultivated extensively in many parts of the world for its succulent fruit (Srinivasan, 2010). Adu-Dapaah and Oppong-Konadu (2002) also noted that tomato cultivation in Ghana forms a key farming activity for people living in the savannah and forest savannah belts of the country. Tomato is very nutritious and forms a vital component of the food consumed worldwide. Tomato with its high per capita consumption in Ghana constitutes one of the commonly grown, marketed vegetables used in almost all Ghanaian homes (Adazabra, Appiah – Kubi, & Bamford, 2013; Asare-Bediako, Showemimo, Buah, & Ushawu, 2007). It consists of assortments of vitamin A, C, riboflavin, carbohydrate, protein, calcium and carotene, which are very essential in our diets (Bull, 1989; Purseglove, 1979). The lycopene in tomato is a healthy phytochemical, with many health benefits including cancer prevention (Bratianu & Schwontkowski, 2013).

The tomato industry refers to a division of the crop sector responsible for the production, processing and marketing of tomatoes and production inputs. Tomato production over the past few decades was envisaged as one of the key drivers of both rural and urban economies in Ghana through job creation and poverty alleviation (Asare-Bediako et al., 2007; Sugri et al., 2013). Following Sugri et al. (2013), tomato production in the Upper East Region is noted as an antidote for the widespread unemployment and poverty for the majority of households. This important role played by tomato production in the Ghanaian economy has been degressive due to several production, marketing and processing challenges, among which include high unit cost of production, inadequate ready market for tomato produced at irrigation sites and increased preference and demand for Burkinabe tomatoes (Bortey, 2010; Haruna, 2012; Robinson & Kolavalli, 2010a).

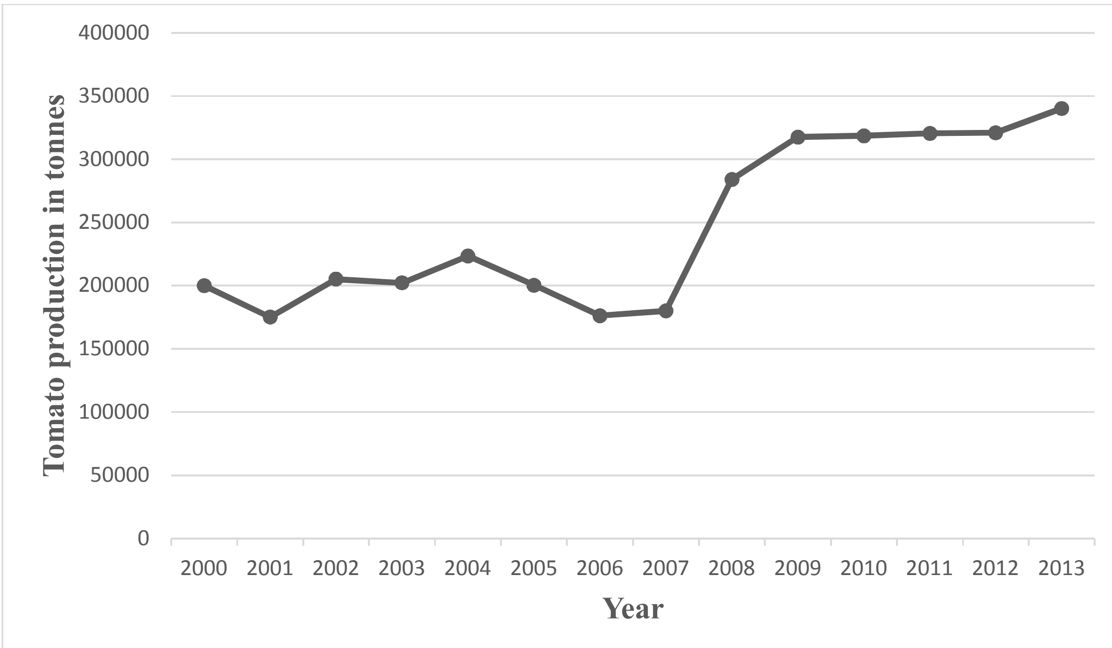
Production of tomato in Ghana is characterised by low average yield emanating from the use of low quality local varieties, high perishability rate, inadequate ready market, competition from imports, and suboptimal land husbandry practices (Adu-Dapaah & Oppong-Konadu, 2002; Robinson & Kolavalli, 2010a). The increasing cost of irrigation emanating from the rising levels of fuel prices and pump maintenance tends to also pose a challenge on irrigated production. These constraints have thus contributed to low productivity of tomatoes in the country. This situation makes it seemingly difficult to cater for domestic demand locally.

Various agricultural development programmes in developing countries have been geared towards increasing the productivity of farmers, by making productive resources (inputs) relatively accessible and affordable to farmers. These programmes, however have placed less emphasis on how these resources are utilised for productivity gains. Some of these programmes undertaken in Ghana include the fertilizer subsidy programme and the establishment of Agricultural Mechanization Centres, the Irrigation Development Programme and the tomato processing infrastructure at some major tomato growing districts like the Northern Star Tomato Factory at Pwalugu in the Talensi Nabdam District in the Upper East Region. Efficient supply of inputs is crucial, but not sufficient in meeting production targets because the intended purpose might be a fiasco if the right amounts are not applied. It has therefore been argued by Lubungu, Burke and Sitko (2014); Quiñones and Diao (2011) that the appropriate utilisation of agricultural inputs has the potential of influencing the efforts of farmers significantly. Rejesus, Heisey, and Smale (1999) also noted that productivity gains in agriculture are dependent on improving the utilisation efficiency of the agricultural resource base. This therefore requires a wider access to information and improvement in management potential of farmers rather than the intensification of the use of these resources.

1.1.1 Tomato Production and Yield in Ghana

According to Robinson and Kolavalli (2010a), available data indicate that the production of tomatoes in Ghana has been erratic; during the period of the 1970 to 1980, production fell from 100,000 tonnes to 50,000 tonnes per annum and the period of 1990 to 2000 also realised an increase in annual production to about 200,000 tonnes per annum. Figure 1.1 gives an illustration of Ghana's tomato production from the year 2000 to 2013. From the year 2000 to 2006, tomato production has not been regular and it took an upward trend from the year 2006 till 2013 where production consistently increased from 176,264 tonnes to 340,218 tonnes (FAO, 2015a).

Figure 1.1 Trend of Ghana's Fresh tomato production (2000-2013)



Source: FAO (2015a)

Tomato production in Ghana has been estimated to have an annual achievable yield of 15 tonnes per hectare, but the actual yield stands at 7.5 tonnes per hectare, thus giving rise to a yield gap of 50% (Ministry of Food and Agriculture (MOFA), 2011). It has been argued by Robinson and Kolavalli (2010a) that if low yielding farmers in Ghana are able to increase their annual yields to 15 tonnes per hectare, then domestic production would be able to cater for the country's consumption and industrial needs. The wide yield gap in Ghana's tomato production can be considered as a contributory factor in rendering the country incapable of meeting the ever increasing fresh tomato needs through domestic production. The deficit in fresh tomato supply is annually catered for through importation from neighbouring Burkina Faso (Horna, Smale, & Falck-Zepeda, 2006).

The production of tomato in Ghana is mainly carried out by smallholder farmers, this can therefore be a contributory factor to the deficit in supply, since they may not have the capacity to expand their production. According to Robinson and Kolavalli (2010a), the tomato industry in Ghana is also characterised by low productivity, high input cost and high yield gaps. The aforementioned characteristics of the tomato industry could be viewed as factors which challenge the economic viability of the industry.

1.1.2 Tomato Based Systems in Ghana

Tomato strives well over a vast range of edaphic and ecological conditions. Ghana is composed of five major ecological zones, with a diminishing trend of rainfall along the South-North gradient (MOFA, 2011). The northern sector is characterised by Guinea Savannah and moving to the south gives rise to the Transitional Zone, Deciduous Forest, Rain Forest and Coastal Savannah zones.

Tomato production in Ghana is categorised into rain fed and irrigated production. The rain fed system of crop cultivation depends mainly on rain (natural causes) to supply the water needs of crops. Robinson and Kolavalli (2010a) argued that tomato production in Ghana is mainly seasonal in nature and thus reflects differences in access to water and rainfall pattern. Inferring from a three regional field survey conducted by Robinson and Kolavalli (2010a) in 2009, it could be deduced that Ghana's Upper East Region and Burkina Faso which operate on the irrigated system supply virtually all the country's fresh tomato needs during the period of December to May. They also noted that production usually pick up in the southern Ghanaian regions later in the year (June to November). Tomato production in the southern Ghanaian regions is mainly done under the rain fed system. The type of production system practised (rain fed or irrigation) has a significant influence on the costs of production and level of yield. According to Robinson and Kolavali (2010a), tomato production under the rain fed system in general is characterised by low input-low yield across regions, while irrigated production is considered as either high input-low yield or high input-high yield depending on the region and the type of irrigation system (public or private and with or without the use of motorised pumps) adopted.

1.1.3 Irrigation Systems in Ghana

Irrigated crop production refers to the process of meeting the water needs of crops through artificial delivery. Namara, Horowitz, Nyamadi and Barry (2011) broadly classified the different types of irrigation systems in Ghana into public and private irrigation systems based on the ownership and management systems practised. Namara et al. (2011) referred to public irrigation schemes as irrigation systems initiated and managed by government or NGOs. Public irrigation schemes in Ghana are managed by ICOUR and GIDA with farmers paying fixed levy per given piece of land for the usage of water. On the contrary, private irrigation schemes are initiated and managed by private entrepreneurs and farmers (Namara et al., 2011). Examples of private schemes include tube wells, small motor-based, out-grower system inter alia. Namara et al., also argued that private irrigation schemes are overshadowing the public schemes in terms of land area irrigated, yields, production levels and value of production. They also asserted that the private irrigation schemes are chiefly developed for the cultivation of horticultural crops, while public schemes are aimed at rice production. The actual cost that farmers pay for irrigation water is generally lower for public irrigation schemes than for privately managed schemes, and this is because most public irrigation schemes in Ghana are subsidised by government.

Depending on the source of water and topography of the irrigated area, water is often distributed via the use of pumps, gravity or both. When pumps are employed to lift water onto the field, be it a public or private scheme, the irrigation costs tend to be higher than schemes that do not utilise pumps, and this is due to the additional costs incurred in the fuelling and maintenance of motorised pumps. Thus, irrigation schemes which employ the use of pumps are most expensive than those which do not. In Ghana, irrigation technologies and cost differ by region and within the region (Robinson & Kolavalli, 2010a). Tono and Vea irrigation projects are the two main public irrigation schemes in the Upper East Region, and they are managed by ICOUR. Though the gravity system of irrigation is practiced under the Tono and Vea irrigation schemes, farmers at the far ends of the irrigation canals usually use motorised pumps to lift water into their fields. The public irrigation authorities usually charge some fixed levy per unit area of land for the supply of water to farmers. This levy is paid by both pump users at the far ends of the irrigation canals and non-pump users situated near/close to the water canals.

Robinson and Kolavali (2010a) argued that irrigation does not seem to have a significant impact on yields, but constitutes a key driver of production cost. Though the amount of money allotted for purchased inputs often differ between public and private irrigation systems, Robinson and Kolavali (2010a) noted that purchased inputs are generally significant in both rain fed and irrigated systems of production. The use of irrigation to ensure constant supply of moisture for crop (tomato) production tends to raise the cost of production over the production under rain fed. This is because the crop's water needs under the rain fed system are generally met through natural causes at no economic cost, whereas the irrigated system incurs a direct economic cost for the supply of water. The foregoing analysis of the systems of tomato production in Ghana suggests that the average cost of production per hectare is higher for irrigated production than the rain fed system of production.

1.1.4 Seasonality of Tomato Production in Ghana

Haruna (2012), noted that "in Africa, the production and supply of many agricultural commodities is largely seasonal" (p. 2). Following Amikuzunu and Ihle (2010), the effect of seasonality on the production of commodities is multidimensional and does not only affect the quantity and quality of the commodity supplied, but also, other key variables on market performance, such as market infrastructure, arbitrage decision, and levels of transaction costs, prices and trade flow between spatially connected markets. Amikuzunu and Ihle also noted that the effects of seasonality of production are evident in the production and marketing of tomato in Ghana. Tomato production across the ten administrative regions of Ghana is seasonal in nature and also depends on the type of production system (rain fed or irrigated) practised. During the peak season in a particular region, prices of tomato usually fall due to temporary gluts that are often created. Hence, farmers profit levels per tonne of fresh tomato falls. Following the peak period in a particular region is a period of scarcity that is often catered for by other regions in the country or through importation. The seasonal nature of tomato production in Ghana therefore affects the annual level and value of output produced and traded. In this regard, tomato farmers in Ghana are often exposed to high market risk (Attoh, Martey, Kwadzo, Etwire & Wiredu, 2014). Hence, influencing their (farmers') decision on the level of total output to produce. Due to the perishable nature of fruits and vegetables such as tomatoes, seasonality is chiefly observed in their production (Amikuzunu, & Ihle, 2010). The perishable nature of tomato usually force farmers to sell their tomato at whatever price offered them, and this is predominantly observed during major harvesting seasons (Yilma, 2006). This therefore serves as a disincentive to commercialise production.

1.2 Problem Statement

Ghana has favourable environmental conditions throughout the country suitable for the cultivation of tomatoes all year round. In spite of the country's potentials and intensification of tomato production nationwide, the tomato industry in Ghana has failed to reach its potential, in terms of yields comparable to other countries, in terms of processing, marketing and improvement of the livelihoods of those households involved in the tomato production and marketing chain (Robinson & Kolavalli, 2010a).

Tomato production in Ghana has consistently fallen below domestic demand, thus resulting in a deficit, which is often catered for through importation. Robinson and Kolavalli (2010a) noted that through the arbitrage activities of tomato market queens, about 100,000 tonnes of fresh tomatoes are imported annually into Ghana from Burkina Faso to supplement domestic supply/production from the months of December to May, and during this period Ghana usually relies mainly on irrigated production from the Upper East Region. These factors have thus raised concerns about the viability of the tomato production in the country, and the Upper East Region, which plays a key role in the country's tomato production is no exception.

In spite of the high use of purchased inputs in tomato production in Ghana, tomato yield is still low. It has been reported by Robinson and Kolavalli (2010a) that high unit cost of production is a source of concern for tomato farmers in Ghana, and this coupled with the yield gap thus creates doubts about the efficiency of allocation of scarce resources in tomato production in the country. Adu-Dapaah and Oppong-Konadu (2002), also attributed the low tomato yields in Ghana to poor management practices and the level of adoption of productive inputs like fertiliser and improved varieties. Robinson and Kolavalli further states that though the cost of tomato production in the country is generally high relative to other countries, irrigated production in the Upper East Region has the highest average cost of production relative to other regions sampled for their study. It is therefore the desire of this study to empirically assess how optimally tomato farmers are allocating production resources (inputs) in the Upper East Region to enhance profitability.

It has been argued by Rejesus et al. (1999) that the role of allocative efficiency is imperative to improving productivity. Rejesus et al., further noted that during the post green revolution phase, farmers realised increased productivity gains as a result of adjusting the use of purchased resources towards their optimal levels, thus stressing the role of efficiency in achieving overall enterprise (farm) profitability. Notwithstanding the indispensable role of allocative efficiency in productivity and profitability, there appears to be less attention to its enhancement, with most empirical studies on efficiency in tomato production in Ghana been geared towards technical efficiency. Hence, literature on allocative efficiency of tomato production in Ghana appears to be scanty.

In the light of the aforementioned arguments concerning the production of tomato, there is an increasing need for an investigation into the profitability of production and the efficiency of allocating production inputs in the Upper East Region.

It is therefore against this background that this study seeks to answer the following questions:

1. How profitable is the production of tomato in the Upper East Region?
2. What are the determinants of tomato yield in the Upper East Region?
3. How efficiently are productive resources allocated in the production of tomato in the Study area?

1.3 Objectives of the Study

The main objective of the study is to analyse the allocative efficiency of irrigated tomato production in the Upper East Region.

The specific objectives include:

1. To determine the profitability of tomato production in the Upper East Region.
2. To identify and quantify the factors influencing the value of tomato yield in the Upper East Region.
3. To evaluate the allocative efficiency of resource use in tomato production in the study area.

1.4 Justification of the Study

The impact of tomato production is multidimensional, ranging from poverty reduction, employment generation, enhancement of nutrition and health among others. Tomato is classified as the most important economical vegetable crop extensively cultivated and consumed worldwide (Redden et al., 2015). The intensification of tomato cultivation has the potential of ensuring nutritional balance, employment generation and counteracting profound poverty in Ghana. These goals can thus be accomplished with productivity levels that are remunerative enough to influence farmers not to divert their factors of production into other enterprises at the expense of tomato production. In order to enhance productivity in production, there is the need for a better understanding of the production system, since this will serve as a guide in decision making. In the light of this, the study is relevant pertaining to the fact that it will provide an insight into the driving forces of tomato productivity to enhance a profitable and efficient production system.

Following Abdulai (2006), an efficient production system is crucial to achieving increased production. Salassi and Deliberto, (2011) argued that farmers are annually challenged with making critical management decisions relating to the allocation of production inputs effectively in various farm enterprises. An efficient production system facilitates the allocation of production resources appropriately among alternative uses (Abdulai, 2006). In this regard, the gross margin analysis coupled with the analysis of allocative efficiency will help in providing information that will aid in farm planning to enhance effective and efficient utilisation of input resources.

Much research has been carried out on agricultural crops, with much emphasis on food security crops such as maize and rice. Available literature suggests that there exist limited studies on vegetables of which tomato is no exception. Abdulai (2006) noted that most of the few studies on vegetables are focused on releasing new varieties, agronomy and physiology with less emphasis on production efficiency. This study will thus add to existing knowledge by making information available to private investors and policy makers in making informed decisions that will enhance profitability.

1.5 Organisation of the study

Chapter two presents the conceptual framework under which this study is conceptualised and a review of relevant literature on the agronomic practices for efficient tomato production. The literature review extends to the marketing of tomato and topics on the concept of efficiency as a means of enhancing productivity. Chapter three presents the study area, methods and tools for data collection and also examines the empirical specification of models for the estimation of various objectives. Chapter four gives the results and discussions of profitability, the determinants of yield and resource use efficiency. Summary, conclusions and recommendations of the study are also presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the conceptual framework and a review of relevant literature to help provide a cogent understanding to this study. The review of literature further provides insights into the resource market, agricultural productivity, and allocative efficiency.

2.2 Conceptual Framework

This section gives a framework within which this thesis is conceptualised. The framework cogently explains the impact of efficiency on agricultural profitability. Several factors such as the supply of productive resources (inputs), however, affect productivity, which in turn exerts a consequential effect on profitability. Discussions in this chapter (two) further assert that Institutional arrangements, production system, supply of productive resources, farmers' level of education, effective extension education and many other factors largely affect the efficiency, productivity and profitability of tomato production in Ghana.

The link between efficiency, productivity and profitability in the production of tomato in Ghana is not well established. Samboko (2011) argued that a well-functioning input market is one of the factors that indirectly determine the farm productivity and also affects the profitability of farming and input access. Evidence from literature suggest that the use of agricultural inputs can substantially enhance agricultural productivity (Crawford, Jayne &

Kelly, 2006). This fact therefore stresses the need for an efficient market for agricultural input, since this will help farmers obtain needed input quantities to boost production.

The liberalisation of the agricultural inputs sector has adversely affected the productivity of farmers, as it is noted by FAO (2005) that farmers' utilisation of productive resources like fertiliser declined following the liberalisation of the sector. This situation was attributed to high cost of inputs emanating from the removal of subsidies. Government's role in enhancing the access to agricultural production inputs is imperative and this can be done by revising the policy framework that governs the agricultural inputs market. To help ameliorate the problem of low usage of farm inputs in the country, the government of Ghana reintroduced the subsidy on some agro inputs like fertiliser and improved seeds in 2008. The implementation of subsidy programmes for agricultural inputs is expected to increase farmers' access to these inputs in a cost efficient manner.

Though an increase in the use of inputs has the capacity to enhance optimal productivity, the attainment of this goal may be a fiasco without the enforcement of appropriate management practices. In order for farmers (tomato farmers) to make efficient production decisions concerning the use (allocation) of agricultural inputs and mechanisms, there is the need for an effective extension education (Berthe, 2015). Effective extension education is expected to transmit productivity enhancing technologies to farmers. During the green revolution era in the 1960s, this goal of agricultural extension education was greatly realised by farmers in Asia (Berthe, 2015). Efficiency in the use of productive resources (inputs) is key to enhancing productivity gains (Kuwornu, Amegashie & Wussah, 2012). Government institutions such as the Ministry of Food and Agriculture (MOFA), through their farmer education programmes under the extension service division can help tomato farmers attain increased efficiency. The socioeconomic factors of farmers such as their educational status can also influence the level of their efficiency. Farmers' advancement in education gives them the ability to adopt and adapt improved/modern farming technologies which have the capacity to enhance their level of efficiency and also increase their productivity levels (Oja, Bila & Iheanacho, 2012; Rad, Ates, Delioglan, Polatoz & Ozcomlekci, 2010).

Productivity, which is a by-product of efficiency, thus exerts a consequential effect on the profitability of production, with high productivity leading to increased profits and vice versa. The level of profitability also influences farmers' access to productive resources. High profitability is thus expected to motivate farmers to invest their proceeds in the procurement of productive resources such as fertiliser, improved seeds, and insecticides inter alia.

2.3 Agronomic Requirements for Efficient Tomatoes Production

2.3.1 Plant Population

Tomatoes can be cultivated by either sowing the seeds directly on the field or transplanting seedlings. For the purpose of attaining uniformity and high percentage of emergence, density and development, tomatoes are mostly transplanted (Steduto, Hsiao, Fereres &

Raes, 2012). On the one hand, direct sowing is usually restricted to standard cultivars (varieties), and this method is considered uneconomical for hybrid tomato cultivars due to high seed cost (Steduto, et al., 2012). Hybrid tomatoes usually produce sterile or no seeds, thus compelling farmers to purchase seeds at exorbitant prices season after season.

In the evaluation of plant performance, it is crucial to determine the optimum planting spacing and plant population per hectare (Adebooye, Ajadi, & Fagbohun, 2006). Plant population refers to the number of plants per unit of area of land. For the purpose of this study, plant population refers to the number of tomato plants planted to maturity per hectare (10,000m^2) of land. Plant population is accounted for by the planting rate and the plant spacing. Planting rate refers to the number of plants/seedlings planted per area of land to attain a certain planting population. On the one hand, planting spacing refers to the arrangement of plants in a particular manner to attain some desired plant population. In Ghana, tomato is usually nursed and transplanted unto the field.

Agronomic literature has delineated the influence of spacing and plant population on growth; yield, pests, aspects of physiology and anatomy of different crops. Plant population has the capacity to influence plant soil moisture content. Pederson (2008) argued that higher plant populations conserve soil moisture through early development of canopy which increases the interception of sunlight. Plant spacing determines plant growth and development by influencing the interplant competition for light and other nutrients (Pederson, 2008). The optimum population or spacing for tomatoes to maximise output is determined by a vast range factors, including climate, soil, cultivar/variety, market requirement, and managerial ability of grower inter alia (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003). Pederson referred to optimal plant population as the population, which maximises both yield and profit.

Though there is a wide range of recommendations for tomato spacing and population, MOFA (2011) recommends an optimum population of about 55,555 tomato plants with a plant spacing of 60 cm x 30 cm and a seeding rate of 300 g to 450 g per hectare. It is therefore expected that if tomato farmers in Ghana adopt these recommended plant spacing, population and seeding rate, ceteris paribus, optimum yield of 40 tonnes per hectare would be attained (MOFA, 2011).

2.3.2 Cultivar (Variety)

Tomato is classified as the vegetable with the greatest number of varieties sold worldwide (Sacco, 2008). The availability of a wide range of varieties thus gives farmers the opportunity to choose the desired varieties for planting. Research institutions have been releasing new varieties to enhance the productivity of tomato farmers. The different varieties of tomatoes vary in size, shape, colour, taste, plant type (determinate or indeterminate), disease and pest resistance, and the period of maturity inter alia. Choosing from a pool of tomato varieties can be quite challenging for farmers, since several factors have to be taken into account. KwaZulu-Natal Department of Agriculture and

Environmental Affairs (2003) noted some factors that have to be considered in the selection of tomato varieties for cultivation, among which include:

1. **Fruit quality:** quality of vegetables and fruits is a key determinant of consumer preference for a particular variety (cultivar), and also exerts a consequential effect on the output market (Demand and Supply). Fruit firmness, juiciness, size, shape, colour, shelf life, and uniformity are some of the quality features tomato consumers often demand. In making production decisions, there is the need for tomato farmers to consider the quality needs of the output market in order enable them choose the most appropriate variety for cultivation.

2. **Adaptability and reliability of variety:** farming in general is a risky venture due to producers' (farmers') inability to fully control all factors of production. Field tomato production is also as risky as any other farming enterprise due to unpredictable weather and other uncertainties that are usually associated with the performance of crops. In order to manage/reduce the risk associated with the production of tomatoes, farmers tends to choose varieties that will offer them higher yields even under unfavourable conditions such as bad weather, and pests and disease infestations (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003).

3. **Susceptibility to various diseases and nematodes:** there is a wide range of diseases that affect tomatoes and cause reduction in yield. In order to counteract losses resulting from diseases, there is the need to implement control measures all season round. This is an expensive exercise which reduces the profitability of

production. Hence, making tomato farmers to give priority to varieties that are resistant/tolerant to diseases and nematodes.

4. **The target market:** farmers often produce tomatoes to meet the demands of specific markets such as the fresh/table tomatoes market and the processing/preservation market. The quality features desired by the various markets vary with regard to juiciness, firmness, shape, size, colour and flavour inter alia (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003). To obtain a ready market for fresh tomatoes, farmers need to seriously consider the quality features demanded for in the target market in selecting their varieties for cultivation.

Tomato production literature in Ghana suggests the cultivation of a wide range of tomato varieties nationwide (Adubofour, Amankwah, Arthur & Appiah, 2010; Clottey, Karbo, & Gyasi, 2009; Ellis, Olympio, Mensah, Adu-Amankwa, & Tetteh, 1998; Robinson & Kolavalli, 2010a), examples of such varieties include Pectomech, Tropimech, Roma, Bolga, Ashanti, Nimagent F1, Rasta, Power, Power Rano, and Wosowoso. The varieties cultivated do not vary much from what has been recommended by the Ministry of Food and Agriculture (MOFA). MOFA (2008) recommended a number of tomato varieties suitable for cultivation in Ghana, and these varieties include Roma VF, Pectomech, Pectomech VF, Tropimech, Rio Grande, Cac J, Wosowoso and Laurano 70.

2.3.3 Planting period

In the Northern Hemisphere, sowing of tomatoes usually commence from the end of February to May, while sowing period ranges from August to mid-December in the Southern Hemisphere (Steduto, et al., 2012). In cases where tomatoes are transplanted, the period of transplanting ranges from the end of March to the end of June – early July in the Northern Hemisphere whereas transplanting in the Southern Hemisphere ranges from September to mid- December. Steduto et al. (2012) argued that the season for tomatoes in the tropics and subtropics is not well defined.

Though the cultivation of tomatoes in Ghana is seasonal, it can be planted all year round depending on the availability of irrigation facilities and suitable climatic conditions for the crop. Tomatoes cultivation is mainly influenced by the availability water. The Rain Forest, Deciduous, Transitional and Costal ecological zones of Ghana are characterised by a bimodal (major and minor) rainfall pattern. The major rainy season for these ecological zones usually occurs between March and July annually, while the minor season occurs between September and November (FAO, 2005). Rain fed tomato production under any of these ecological zones can be done from March to July and from September to November. The Guinea Savannah and Sudan Savannah Zones have a unimodal rainfall pattern, which stretches from May to September (FAO, 2005). Rain fed cultivation of tomato under the Guinea Savannah and Sudan Savannah Zones can commence from May to September annually. Irrigated tomato production is usually carried out in the Guinea Savannah and Sudan Savannah zones in the dry season, from October to April.

2.3.4 Fertiliser

Various fields require varied soil nutrient compositions to efficiently support the growth of crops. The soil nutrient requirements of a particular field depend on the fertility status of the soil, cultivar (variety), rainfall pattern, and field activities inter alia. To achieve satisfactory yields for tomatoes, reliable soil analyses should be developed for each field to compose a balanced nutrition for the plants. Soil testing is an eminent tool in determining fertiliser needs of plants and should always be conducted prior to planting (MOFA, 2011; Saha, Pfeufer, Bessin, Wright, & Strang, 2016).

For field tomato production, NaaDanJain Irrigation Limited (2012) gave a general recommendation of 20 kilograms of phosphate (P_2O_5) per hectare, and 200 kilograms of potash (K_2O) per hectare as the minimum required levels of fertiliser to support tomato plants with phosphorus and potassium. However, these recommendations do not differ much from those of the ministry of food and agriculture of Ghana. For a yield of 40 tonnes per hectare, MOFA (2011) noted that tomato requires about 96 kilograms of nitrogen, 16 kilograms of phosphate (P_2O_5), 144 kilograms of potash (K_2O), 68 kilograms of calcium (Ca), 24 kilograms of magnesium (Mg), and 24 kilograms of sulphur (S). MOFA also gave a general recommendation of 400 kg of NPK, 100 kg of Potassium Nitrate, and 100kg of Sulphate of Ammonia for the production of a hectare tomato in Ghana.

2.3.5 Staking

Staking is a vital cultural practice in tomato production, which is usually carried out to raise tomato plants above the ground. In Ghana tomato plants (foliage) are usually raised above the ground with wooden stakes. Staking is usually carried out when the plants are about 30 cm tall (Ha, 2015). This exercise often contributes tremendously to improving the marketable yield and quality of tomato fruits. By raising plant parts and fruits above the ground, the incidence of pests and diseases are often reduced. In spite of the advantages of staking, it is however an expensive practice in terms of materials and to some extend labour (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003).

2.3.6 Moisture Quantity/Distribution

Tomatoes need a regular supply of moisture to give good yield. Field moisture for tomatoes should be maintained at about 60% (Tran, 2005). Tindall (1988) argued that erratic irrigation negatively affects the yield of tomatoes by causing fruit cracking and also splitting calcium or potassium in the soil which may result in blossom-end-rot. Water is vital for the growth and development of tomato plants, but excess amounts also lead to vegetative growth and the associated dropping of flowers and newly set fruit (Steduto, et al., 2012). Flowering stage in tomato production is the period in which tomatoes make the highest demand for water (FAO, 2015). Prolonged period of dryness during the flowering period might result in shedding of buds and flowers (Ha, 2015). Tomatoes should be grown in relatively dry areas under irrigation to attain desired results. Prolonged severe moisture deficit impedes growth and also reduces yield, this situation cannot be corrected in later periods through heavy watering (FAO, 2015). Several factors influence the water needs of tomatoes in the field, among which include: weather conditions, drainage and water holding capacity of soil, plant growth stage and growth rate. The weather conditions are vital determinants of tomato water requirements because they often pose a direct effect on the evapotranspiration of crops.

Tomato crops often grow in the field for about 90 to 120 days after transplanting, and require a total moisture (water) content of 400 mm to 600 mm (FAO, 2015). Tomato requires a regular and controlled supply of water throughout the season, this can however be altered under water limiting conditions, where water saving may be done during the vegetative and ripening stages (FAO, 2015). Under such limiting conditions, FAO further noted that the priority should be on maximizing production rather than increasing the area under cultivation.

2.3.7 Temperature – intensity

Tomato is a warm season crop which is sensitive to frost and thrives well under an optimum temperature range of 21 to 27°C for efficient growth and development (Hanson, Chen, Kuo, Morris & Opena, 2001; Shankara, Maijade, Matin & Van Dam, 2005). Temperatures below 12°C and above 35°C, are detrimental to growth, yield and fruit quality of tomatoes (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003). Gent and Ma (1998) noted that low temperatures of less than 12°C adversely affect the yield of many tomato cultivars, and these low temperatures negatively affect fertilisation of tomato plants thus resulting in flower abortion. Low temperatures have also been noted to decrease pollen count and viability, thereby lowering fruit set in tomatoes (Ercan & Vural, 1994). Tomato is largely noted to be a self-pollinated plant, but high temperatures have the capacity of hindering this ability by causing the staminal cone to split and also lead to fasciation of the style (Heuvelink, 2005). Persistent low temperatures have been noted for the shedding of flowers and young fruit, while high temperatures also lead to a reduction in the number of trusses, flowers per truss and an increase of blossom drop and fruit abortion (Steduto et al., 2012).

2.3.8 Photo period

Tomato is a day length neutral crop (Nuruddin, 2001), and requires a minimum of 8 hours of continuous sunlight on daily bases. Light intensity plays a vital role in determining the ascorbic acid content of tomato fruits, the ascorbic acid content has been noted to alternate with varying light intensity (Dzisah, 2013). A research conducted by Hammer, Stewart and Matrone (1943) noted a 66% increase in the ascorbic acid content of tomato fruits, when the fruits were transferred from a shade to sunshine, and this took place at the time the fruits were mature green.

2.3.9 Type of irrigation system

Irrigation is key to the production of tomato under arid and sub-arid climatic conditions, such as Ghana. The intensity of irrigation for tomato varies with varied stages of growth and development of the crop, coupled with the climatic conditions at a given time period.

Pre-planting irrigation is a common practice in the arid area where past rainfall is insufficient to replenish the soil profile for planting (Steduto et al., 2012).

The most commonly practised type of irrigation employed in tomato production is surface irrigation by furrow, though in recent times, some major tomato cropping countries have resorted to the use of pressurised irrigation methods such as sprinkler, mini- sprinkler and drip (Steduto et al., 2012). The selection of a particular irrigation method for practice should be guided by the pros and cons of the various methods and their impact on the marketable yield and quality of the tomato fruits. In cases where sprinkler irrigation has been employed in the production of tomatoes, the occurrence and spread of fungal and bacterial infections have been noted to be a possible cause of concern because the continuous wetting of leaves creates a conducive environment for the breeding of fungal and bacterial canker (FAO, 2015). FAO (2015) further noted that sprinkler irrigation has a high tendency of reducing fruit set and to also intensify fruit rotting. In terms of fruit cracking, furrow irrigation has an advantage over sprinkler irrigation. The use of furrow irrigation is also hampered by the inefficiency in the use of water. Trickle or drip irrigation can meet specific water needs without wetting the leaves of crops, this is usually done by directing water to the root zone. This method possesses the potential of ensuring efficient water management while meeting crop soil water needs. However, furrow irrigation is predominantly employed in the production of tomato in Ghana.

2.3.10 Time of Harvesting

Harvesting refers to the process of gathering the yield of a crop (tomato) at the end of its growth cycle. Harvesting marks the end of the growth cycle of a crop and the beginning of its marketing (Camelo, 2004; Yeboah, 2011). Many fruits and vegetables can either be harvested mechanically or manually, but it is most appropriate to harvest table tomatoes manually because all the fruits do not usually mature at the same time. According to Orzolek et al. (2006), harvesting fresh tomatoes is labour intensive and requires multiple pickings. The delicate nature of tomato makes it require intensive care during harvesting so as to prevent mechanical injuries which would subsequently result in the formation of pathogens.

Barbosa-Cánovas et al. (2003) states that the maturation of a fruit serves as an index of its readiness for harvesting. The principles determining the stage of maturity at which fruits or vegetables should be harvested significantly influence the storage and marketable life and quality of these fruits or vegetables (Barbosa-Cánovas et al., 2003). Post-harvest physiologists have distinguished three stages in the life span of fruits and vegetables which include: maturation, ripening, and senescence (Barbosa-Cánovas et al., 2003). These stages follow each other systematically from maturation to senescence.

According to Gast (1994), the stage of maturity at which tomatoes should be harvested depends on the end use (whether for fresh/table or processing) and the distance to the market where they will be sold. Gast further noted that tomatoes are harvested mature green, vine-ripe, breaker stage and ripe. Following Orzolek et al. (2006), tomatoes produced for the wholesale market should usually be picked at the mature green to breaker stage to prevent the fruits from becoming overripe during long transportation/shipping and handling. Orzolek et al., further recommends leaving tomatoes on the vine to ripen if they can be sent to market quickly and in good condition.

Gast (1994) observed that high temperatures have a negative impact on perishable produce such as tomato, because these high temperatures usually increase the rate of respiration of the fruits which in turn lead to a reduction in shelf life as a result of fast tissue growth (tissue senescence). Gast further argued that it is appropriate to harvest fruits and vegetables during the coolest part of the day, especially in the morning so as to help prolong the shelf life and also prevent postharvest disease problems.

2.4 Resource/Input Market

2.4.1 Resource/Input supply sector in Africa

The input supply sector refers to a division of the marketing sector that makes production inputs available and accessible to farmers effectively to enhance productivity. In the light of the significant role (provision of required inputs) played by input suppliers in the production process, Yakubu (as cited in Robinson & Kolavalli, 2010b), thus identified the sector as a powerful agency which directly influence agricultural productivity. In this regard, efficient supply of agricultural production inputs to farmers is very crucial in meeting productivity targets. Some of the inputs that are usually employed in the cultivation of tomatoes include the following: tomato seeds, fertiliser, weedicides, fungicides, labour, land, capital inputs, credit, and irrigation facilities. Operationally, the input sector takes into account only purchased inputs such as fertiliser, seeds, herbicides, weedicides, and mechanisation services.

Results of the Green Revolution in Asia have proven that increased use of inputs is directly linked to productivity gains. An increase in the use of agro-chemicals and improved seeds can equally lead to a Green Revolution for the African continent and thus lead to massive productivity gains (Krausova & Banful, 2010). Before most African countries embarked on their economic recovery programmes, spearheaded by the Bretton Woods Institutions during the 1980s and 1990s, various African governments realised the role of agro inputs in enhancing crop productivity. As a consequence, they took the initiative and instigated programmes that would promote the use of these inputs. Governments at the time played a key role in the supply of agro inputs from procurement to distribution to farmers. Governments' programmes in enhancing increased use of productive inputs have relied significantly on subsidies (such as subsidies on agro chemicals like fertiliser) which were considered financially unsustainable (Krausova & Banful, 2010). Following the poor economic performance of countries in the African sub-region, a general agreement was met to privatise the state managed agricultural input sectors in these countries in order to increase their fiscal space and also curtail the abject drawbacks associated with the sector (Freeman & Kaguongo, 2003). In many African countries, the main goal of governments' before and after the liberalisation of the agricultural input sector is to influence farmers to increase the use of agricultural inputs to boost productivity. It was expected that the liberalisation of the agricultural inputs sector will enhance efficiency in the distribution of agricultural inputs to help increase agricultural productivity (Krausova & Banful, 2010).

Though the agricultural inputs sector was privatised (liberalised) to improve efficiency, this intend has not been realised as farmers find it expensive obtaining inputs from the liberalised inputs market. Following the initiation of the liberalisation policies in the inputs sector, the use of fertiliser in West Africa decreased from 15kg/ha in 1980s to 12-13kg/ha in the 1995 and 1996 (World Bank, 2000). This signifies that the private sector might have digressed from the goal pursued by governments in increasing agricultural productivity via increased utilisation of purchased inputs like fertiliser (Krausova & Banful, 2010). The decline in the use of purchased inputs might be attributed to the removal of government subsidies following the privatisation of the sector. Hence the existence of government support to agriculture, such as subsidies on productive inputs is vital, since it increases farmers' chances of obtaining the needed quantities of agricultural production input to boost growth in productivity.

Following Crawford, Kelly, Jayne and Howard (2003); Morris, Kelly, Kopicki, and Byerlee (2007), private investment in the agricultural inputs sector in many African countries is challenged by unfavourable business climate characterised by government interference; macroeconomic instability; inadequate regulatory systems; and some entry barriers. Some of the noted entry barriers include: high taxes and fees, inadequate funding, poor ports, rail and road infrastructure, non-competitive behaviour of suppliers and policies and institutions that restrict competition and increase marketing cost. These challenges of the agricultural input sector, thus impair the efficient flow of production inputs from the dealers to farmers in time and space.

In spite of the challenges faced by the private sector in the trade of agricultural inputs, some African countries such as Kenya have made remarkable progress in the private sector led agricultural inputs market development which thus enhances the utilisation of purchased inputs in substantial quantities (Krausova & Banful, 2010). For instance, Ariga and Jayne (2009) noted that within the period of 1990 and 2007 the annual utilisation of fertiliser by smallholder farmers in Kenya increased from 56% in 1996 to 70% in 2007. This trend in the usage of fertiliser might be as a consequence of some government policies, such as subsidies. In this regard, the role of government in ensuring that smallholder farmers obtain needed quantities of inputs to enhance productivity in agriculture is indispensable.

Despite the tremendous role of an efficient input market in supplying farmers with needed inputs to optimise production, the output market on the other hand determines a farmer's decision on the purchase of productive inputs. The availability of a ready market for farm produce suggests the availability of credit to acquire productive inputs. The two markets are interdependent, and the efficiency of either of the markets affects the operations of the other. Kahan (2013) asserts the interdependent role of the input and output markets by noting that the fluctuations in prices in these markets often affect farmers. The combined effect of these two markets on production is enormous and plays a key role in farmers' investment decisions on the adoption of new and more productive agricultural technologies (Abebe, 2011; Oehmke, Anandajayasekeram, & Masters, 1997). Since profit maximisation is the main goal of virtually all firms, Kahan (2013) noted that crop and livestock farmers should not only produce at efficient levels, but also purchase inputs and sell outputs at prices that result in profit. This is expected to help farmers to survive over the long run.

2.4.2 Resource/Input supply sector in Ghana

According to Krausova and Banful (2010), data on the agricultural inputs supply sector in Ghana is sparse across time and space. In Ghana, prior to the trade liberalisation in the 1980s under the Structural Adjustment Programme (SAP), government institutions (marketing boards) were the sole suppliers of agricultural inputs (Abankwah, Fialor & Aidoo, 2013). The private sector therefore became the sole supplier of agricultural inputs following the trade liberation policies instigated under the SAP, which cuts government's direct involvement in the supply and distribution of inputs to farmers (Quiñones & Diao, 2011). The post-Structural Adjustment era witnessed a decline in the use of agricultural inputs such as fertiliser, and this can be attributed to the lack of government support for the agricultural sector. The decline in the usage of productive inputs is evident in the decline in fertiliser consumption that was recorded in the country (Ghana) from 1984 to the first half of 1990s (FAO, 2005).

Governments over the years have initiated a couple of support programmes to improve upon agricultural productivity in Ghana, most of these programmes are geared towards making agricultural inputs readily accessible and affordable to farmers. Some of these support programmes include subsidy on agro chemicals (such as the fertilizer subsidy programme) and provision of tractor mechanisation services centres inter alia.

Ghana's fertiliser subsidy programme was reinstituted in 2008 as a temporary measure to counteract spikes in food, energy and fertiliser prices in the country in 2007-2008 (Banful, 2010; MOFA, 2013). In spite of the efforts made by governments in the provision of inputs, the private sector still remains the sole supplier of agricultural inputs (including fertiliser) (Quiñones & Diao, 2011). Government's role in the agricultural inputs (fertiliser) market is passive, through the provision of subsidies and does not play any major role in the procurement, importation and distribution of these inputs (Banful, 2010). In the absence of government subsidies on inputs like fertiliser, smallholder farmers usually find it challenging in raising funds to purchase the appropriate input (fertiliser) quantities to enhance productivity.

The fertiliser sector in Ghana was liberalised in 1991 (Banful, 2010), and still operates as such, though government plays a passive role in the sector, through the provision of subsidies. Prior to the implementation of the fertiliser subsidy programme in 2008, Ghana's fertiliser market was noted as one of the most liberalised input markets in sub-Saharan Africa (Baltzer & Hanser, 2011). The restoration of the fertiliser subsidies in 2008 was aimed at increasing the usage of fertiliser to enhance productivity growth in agriculture. The programme has a set target of increasing fertiliser use rate to at least 50 kg per hectare by the year 2020 as recommended in the Medium Term Agricultural Sector investment programme of the Ministry of Food and Agriculture. After implementing the fertiliser subsidy programme, fertiliser consumption among farmers is still low and is about 35.8 kilograms per arable land (World Bank, 2016). From 2008 to 2013, the government of Ghana progressively pursued the fertiliser subsidy programme (Banful, 2010; Government of Ghana, 2016). In 2014 however, the programme did not take place and this could be attributed to the significant slowdown in the Ghanaian economy since 2013. The high cost of the fertiliser in 2014 hindered the productivity of some impecunious farmers, due to their inability to purchase appropriate quantities of fertiliser for production. However, the fertiliser subsidy programme was implemented in 2015.

2.4.3 Input Sources and Transaction Types in Ghana

Virtually all agricultural chemicals, including fertiliser, weedicides, fungicides, insecticides and pesticides inter alia used in Ghana are imported through the nation's ports (Krausova and Banful, 2010). These inputs are often distributed to the end users through various intermediary channels composed of wholesalers and retailers in the ten administrative regions (FAO, 2005). The wholesalers/retailers in turn transmit these inputs to farmers through a network of rural agricultural input dealers in the various districts. FAO (2005) further noted that farmers can also source these agricultural inputs (fertiliser) directly from wholesalers/retailer at the regional level. Krausova and Banful (2010) defined an agricultural input dealer as any institution or establishment that engages in the trade of agricultural inputs.

The work of Krausova and Banful (2010) revealed that the conditions of entry for new firms into the agricultural inputs market in Ghana are easily met, this is affirmed by the high number of new entrants recorded in their study. This suggests the existence of competitive market behaviour, which might go a long way to impact positively on farmers cost of production. On the contrary, the top of the distribution channel appears to be monopolised with only few firms importing these agricultural chemicals. Some of these firms include WEINCO Ghana Limited, Yara Ghana limited, Chemico Ghana Limited, Afcott Ghana Limited and OLAM Ghana among others. The role of these importing firms in determining the consumer price of these inputs is very crucial, in that, whatever action taken by them has a trickle-down effect on the final consumers of the inputs. Considering the undeniable role of the importing firms in determining the market price of inputs, there is the need to ensure that their operations are competitive enough to prevent collusion. FAO (2005) noted that the market price of purchased inputs like fertiliser is determined by the cost of the intermediary activities undertaken by various market actors from importation till the inputs get to the final user, The exchange rate of the local currency to that of the foreign trade partners also play a key role in determining the market price of agricultural inputs. The frequent variation in retail prices of agro inputs like fertiliser in Ghana is a reflection of erratic exchange rates (FAO, 2005). The dependence on imports, thus contributes to the continuous increase in the cost of food production since the local currency has persistently fallen to the major trading currencies especially the United States Dollar (US$).

IFDC (2012), outlined a four dimensional supply chain for the distribution of government's subsidised fertilisers in Ghana. It is noted that all subsidised fertilisers are imported through the nation's ports. The fertilisers are thus transmitted to the end users via any of the proposed channels:

1. Private Importers can transmit fertiliser to agro input dealers in district locations who in turn transmit the input to all farmers.
2. The imported fertilisers can be moved from importers to wholesalers situated in regional locations, these wholesalers in turn transmit fertilisers to agro input dealers in district locations. Fertilisers are then transferred to all farmers from the district dealers.
3. The imported fertilisers can also move from importers to wholesalers in regional locations, which is then transferred to large farmers/industrial crop farmers.
4. Furthermore, the private importers can transmit fertilisers to export Crop Companies such as Cocoa Board, the product then moves to licensed wholesaler which is in turn transferred to licensed agro-dealers/agents. Fertilisers are then transferred from the licensed wholesaler to out grower farmers (growing for export), via licensed agro dealers/agents.

Krausova and Banful (2010) identified the network of input dealers in Ghana to be composed of three broad categories of intermediaries, including table top dealers, general stock lists and specialised wholesalers. Farmers' decision to purchase their inputs from either wholesalers or rural input dealers depends on whichever source that is economically feasible in terms of cost (FAO, 2005). The distance between the wholesaler and rural input dealers influences the cost of transaction of the retailer, which is in turn reflected in the retail price of the inputs. It is expected that if the wholesalers and retailers are found in the same locality, purchasing from the wholesaler might be better in economic terms because the wholesale price would be lower than that of the retail. Hence the distance between the two market agents (wholesalers and retailers) plays a vital role in determining the source from which farmers will obtain their purchased inputs.

2.5 Marketing of Tomato in Ghana

According to Kotler (1991), "Marketing is a social and managerial process by which individuals and groups obtain what they need and want through creating, offering, and exchanging products of value with others" (p. 10). Our operational definition of marketing is that it is a management process which identifies, anticipates and supplies, tomatoes to consumers efficiently and profitably. How efficiently farmers' market tomatoes influence their profit levels which in turn affect their decision to continue producing.

In Ghana, tomatoes can be marketed through various channels/routes. The marketing channels taken by farmers to market fresh tomatoes should be capable of delivering tomatoes to the consumers in the desired form and at an efficient cost, relative to other channels. The fresh tomatoes marketing channel refers to the various routes available in moving the tomatoes from the farmer to the final consumer. Along each marketing channel is a marketing chain which comprises of a series of intermediaries that carry out various activities. Marketing chain refers to various intermediaries/marketing agents (such as farmer, wholesalers, brokers and retailer) that usually undertake various activities in shifting the commodity to the final consumer. Some of the intermediary activities include sorting, grading, packaging, and loading/unloading, transportation, storage and distribution. Though tomato farmers have multiple markets, proximity and availability of market are the key determinants of a particular market chosen by a tomato farmer in Ghana. This dilemma in marketing fresh tomatoes in the country can be partly attributed to the perishability of the crop and the restrictions imposed by "market queens" in marketing tomatoes in the key tomatoes wholesale markets in the country as noted by (Robinson & Kolavalli, 2010b).

Following Haruna, Nkegbe and Ustarz (2012); Robinson and Kolavalli (2010b), various channels exist in the marketing of tomatoes in Ghana and these include:

Farmer ⟹ Regional Traders

Farmer ⟹ Processors

Farmer ⟹ Local Market ⟹ Consumer

Farmer ⟺ Market Queens (Wholesalers) ⟹ Retailers ⟹ Consumers

Robinson and Kolavalli (2010b) argued that the tomato market queens serve as the key bridge between farmers and consumers in urban areas, thus breaking the marketing chain in the industry into a simpler one and reducing the time in moving fresh tomatoes to consumers. The short period of transmission of tomatoes from the farmer to urban markets, aided by the activities of tomato market queens can be seen as a means of reducing postharvest losses that often result from perishability (short shelf life) of the crop (Robinson & Kolavalli, 2010b).

Robinson and Kolavalli (2010b), classified Kumasi and Accra (Makola and Agbogbloshie) to be the key wholesale markets for tomatoes. They further categorised markets located near major growing areas (Navrango, Tamale, and Techiman) as other important markets. With the exception of small markets situated in major production areas, the tomato market queens have developed a strong market power (cartel) which allows them to manage the amount of tomatoes that enter the key wholesale markets in the country (Robinson & Kolavalli, 2010b). The organised nature of the traders also gives them an advantage over farmer, in setting the price of fresh tomatoes and thus reduces the profit margins of farmers (Robinson & Kolavalli, 2010b).

2.6 Profitability of Tomato Production

The economic underpinning of every business activity/firm is profit maximisation, thus entrepreneurs will take informed decisions on the allocation of scarce resources to achieve desired results in the future. Profitability is the long run goal of all business ventures, and the survival of a business in the long run, thus depends on how profitable it is (Hofstrand, 2009).

To enhance coherence in the analysis of profitability, an in-depth knowledge of the costs and returns associated with various activities is desired since the costs and returns form the basis for the computation of profit. Thus, for the purpose of this study, information on the costs and returns components of tomato production is of tremendous importance, since that will help enhance cogent margin analysis of production.

The tomato industry is composed of three major interdependent sectors. These sectors include; production, processing and marketing. For the purpose of this study, profitability analysis on the industry would be focused on the production sector. The tomato production sector refers to the section of the industry responsible for the acquisition and utilisation of inputs (factors) (labour, land and capital) to achieve some desired output (tomatoes). Operationally, the tomato marketing sector also refers to the section of the industry that supplies farmers with inputs and also ensures the trade of fresh tomatoes.

Oluwadare, Imoudu and Ogundari (2009) employed gross margins to analyse the profitability of Palm Oil Marketing in Ondo State, Nigeria. The conventional gross margin formula was adopted and calculations were done on a per year basis. The results obtained from their study indicated that oil palm marketing in the study area is profitable. Afolabi, Adegbite, Ashaolu and Akinbode (2013) also used gross margin and net income to compute the Profitability of poultry egg farming in Ogun State, Nigeria. The results of the gross margin and net income showed that, poultry egg farming was profitable. The net income analysis has certain drawbacks such as the difficulty to accurately compute the total cost. This could result from the difficulty in valuing unpaid farm labour and management. Gross margin analysis has an advantage over net margin analysis because it gives estimates and does not erroneously conclude on overall cost and returns that might be miscalculated. Gross margin only gives a simplified picture of profitability, by considering only variable cost. On the one hand, gross margin analysis cannot also be used to assess the overall profitability of an enterprise since it does not take into account all the cost components, whereas, net income analysis has an advantage over this. Hence, for the purpose of this study the conventional gross margin formula was applied in analysing the profitability of irrigated tomato production. It can be expressed as:

$$GrossMargin = \sum PQ - \sum_{i=1}^{n} p_i \, q_i \qquad (1)$$

Where: P= price of tomato per tonne

Q= total quantity of production of tomato per hectare

p_i= price of ith input

q_i=quantity of ith input

2.7 Agricultural Productivity

Agricultural productivity refers to the transformation of a given level of input(s) into output in the agricultural sector of a given economy (Fulginili & Perrin, 1998). Productivity is a measure of efficiency, since the result of the output to input ratio depicts a simplified picture of returns from engaging a given set/level of inputs. There exists a varied range of productivity measures, and the choice between them is influenced by the purpose of the productivity measurement and the availability of data (OECD, 2001). The measures of productivity are broadly categorised into single factor productivity measures (relating to the ratio of output to an individual input) or multifactor productivity measures (relating to the ratio of output to a bundle of inputs).

Kuwornu et al. (2012) argued that growth in productivity constitutes one of the key determinants of per capita income growth in all economies. Tetteh (2013) also notes that

"Higher productivity of agricultural resources lowers production costs, increases output (often involving less land), and releases some resources (such as labour) from agriculture to other sectors of the economy" (p.20). This implies that the productivity of productive resources in agriculture often exerts a consequential effect on the profitability of farm enterprises with higher productivity levels leading to higher profitability and vice versa. Mallawaarachchi et al. (2009) also argued that higher agricultural production (expansion), which is the reciprocal effect of high productivity leads to lower commodity prices, hence, passing some of the benefits of innovation onto the food industry and consumers and also promotes general economic growth. The indispensable role played by productivity in ensuring food security and economic development has been recognised worldwide and captured in the millennium development goals. The millennium development authority has set an annual agricultural productivity target of 6% against the year 2015.

Mallawaarachchi et al. (2009) observed that within the boundaries of agricultural production, the principal inputs of production, which influence productivity include land, labour, capital and material inputs, while outputs include crop, forestry and livestock products. Literature has further unveiled quite a notable amounts of other factors that affect productivity changes in agriculture and these factors include research and development, extension, education, infrastructure and government programmes inter alia (Osteen, Gottlieb & Vasavada, 2012). An understanding of the determinants of productivity has the potential to influence policies and producers' decision making abilities. Improvement in productivity also increases the economic fortunes of farmers.

2.8 Determinants of Agricultural Productivity

2.8.1 Influence of Land on Agricultural productivity

Land forms the productive unit for virtually all agricultural activities. For smallholder farmers who depend solely on agriculture for their livelihoods, land is one of their key productive resources (Tetteh, 2013). Land is the first factor of production, whose value is determined by the potential uses and locality (United States Department of Agriculture (USDA), 1997). In Ghana the competition for land for various purposes like real estate development is intensifying, this has not spared arable land apportioned for crop production. This trend in the use of land in Ghana, coupled with population growth has resulted in the fragmentation of agricultural land. As a result of land fragmentation, crop farmers have been confined to fixed pieces of land for cultivation, which results in loss of fertility over time. The loss of fertility in the land in turn causes productivity to decline.

Though crop productivity is associated with intensive use of improved inputs, productivity can also be enhanced through better land management and farming practices (IFPRI, 2010). Abdulai (2006) asserts that the type of land tenure/ownership practiced by farmers exerts a consequential effect on their production efficiency. According to Randela (2005), land ownership can influence the productivity of agriculture in the sense that farmers who do not own land might be reluctant to develop and maintain the land(s) under their use. This is mostly due to the fear of them been displaced at any point in time by the rightful owner(s). Land serves as a key collateral to farmers, and farmers who do not own land (land titles) may find it difficult obtaining loans from financial institutions due to lack of collateral security (Tetteh, 2013; Reddy, 1998). As a consequence, farmers may find it tough obtaining required inputs (such as fertiliser, weedicides and fungicides) to enhance the productivity of crop production. In the light of the role of land ownership in productivity gains, Kabutha (1999) emphasised the need for a secure land tenure so as to give farmers the morale to efficiently use land and to invest in land conservation and improvements that are closely linked to both productivity and sustainability.

2.8.2 Influence of Labour on Agricultural Productivity

Labour is also one of the fundamental inputs needed for production, most especially in small scale farming (Tetteh, 2013). Smallholder agriculture is labour intensive, which tends to use manual labour for virtually all production operations, thus indicating that farmers use large quantities of manual labour to carry out production activities (Tetteh, 2013). Considering the vital role played by labour in small scale farming, its shortage during certain stages of the production process like the harvesting of vegetables may be very expensive, taking into consideration the amount of losses (Xaba & Masuka, 2013). The intensive use of manual labour by smallholder farmers, might be the only way of getting the work done due to lack of funds to invest in capital intensive operations. According to World Bank (2009), agricultural labour is classified into three distinct classes as unpaid labour (family labour), paid -in-kind (labour exchange or barter), and self-employed or wage labour. Smallholder farmers refer to farmers who extensively depend on family labour to cater for virtually all labour needs of their farms (Thepa, 2009). Hence, the over reliance on family labour by smallholder farmers (who are considered poor) for their farm operations therefore signifies that family labour is the first-hand labour for carrying out production operations, since farmers do not need to hold cash to employ the services of family members.

2.8.3 Influence of Material Inputs on Agricultural Productivity

Material inputs in agriculture, such as fertiliser, weedicides, improved seeds and insecticides play an indispensable role in enhancing crop productivity. This is evident in the results of the Green Revolution in Asia and Latin America, where increased use of inputs, particularly fertiliser and improved seeds resulted in agricultural productivity growth. IFPRI (2010) also asserts the need to intensify the use of agricultural inputs in the African continent in order to witness a massive productivity growth. The need to intensify the use of modern production inputs like fertiliser, improved seeds, and existing technologies in Ghana's agricultural sector to improve productivity is evident in the yield gap of about 20%-84% recorded for most crops in the country (MOFA, 2013). The foregoing arguments therefore signify that productivity gains in agriculture are directly linked to increased utilisation of material inputs (such as fertiliser, weedicides, herbicides, improved seeds, irrigation etc.) in production. On the contrary, declining yields and low level of farmer income are noted to be the attributes of low utilisation of agricultural input in production (Tetteh, 2013).

Despite the enormous impact of increased use of agricultural inputs on improving productivity, the exponential increase in the cost of many agricultural inputs emanating from the removal of subsidies, price controls and currency depreciation tends to limit the ability of farmers' to acquire and utilise appropriate quantities of these inputs to enhance productivity (Tetteh, 2013).

2.8.4 Influence of Extension Education on Agricultural Productivity

Van den Ban and Hawkins (1996) defined "extension as the conscious use of communication of information to help people form sound opinions and make good decisions" (p.9). Extension is also defined as "an ongoing process of getting useful information to people (the communicative dimension) and then assisting those people to acquire the necessary knowledge, skills and attitudes to utilise effectively this information and technology (the educational dimension)" (Swanson & Claar, 1984, p.1). Agricultural extension has been envisaged as a vital factor in enhancing agricultural development (Anderson, 2007; Anderson and Feder 2007; Birkhaeuser, Evenson & Feder, 1991), through the transfer of improved agricultural technologies and information at the farm levels (Swanson, Bentz, & Sofranko 1998). Investment in agricultural extension services is pertinent to improving agricultural productivity, which consequently increases the incomes of farmers (Anderson, 2007). To improve farmers' productivity, production and livelihoods, various Sub-Saharan African countries have been implementing agricultural extension models such as Training and Visits (T&V), Participatory Approaches, Farmer Field Schools (FFSs), ICT-based on farmers and promotion of model farms (Taye, 2013; Waddington, Birte, White & Anderson, 2010).

2.8.5 Influence of Age on Agricultural Productivity

Age is a possible determinant of a farmer's ability to carry out production operations successfully and efficiently (Dlova, Fraser & Belete, 2004). Younger farmers (farmers within the age bracket of 15 to 64 years) are often more willing to adopt modern farming technologies and also more successful in carrying out various physically demanding farming operations compared to elderly farmers (farmers more than 65 years) (Dlova et al., 2004). This argument is in consonance with literature (Todaro & Smith, 2012), which asserts that people under age 15 and above 64 years are often financially dependent due to lack of strength to carry out various income generating activities.

Notwithstanding the fact that younger farmers are more energetic and capable of working efficiently, Vu (2008) noted that the effect of age in determining the efficiency of farmers is ambiguous: on one hand older farmers are considered more efficient than younger farmers because of their long years of experience in production. On the other hand, younger farmers may be more willing to adopt and adapt more efficient technologies and more physically strong to carry out farm activities relative to older farmers.

2.8.6 Influence of Gender on Agricultural Productivity

Gender has been one of the highly pronounced variables in agricultural production literature that influence productivity. In spite of the fact that females' serve as a fundamental labour force in smallholder farming, their involvement in agriculture across the world is characterised by less resourced and less access to technology inter alia (IFPRI, 2010). These characteristics of females in agriculture, coupled with other factors like their domestic and reproductive responsibilities limit their time for farm work. This therefore impedes their contribution to agricultural production.

Females' access to various productive resources has been the main determinant of their productivity. FAO (2010), noted that females in agriculture worldwide have access to only 20% of land, and their apportioned fields are generally smaller in size and lower in quality. In Ghana, for instance, the land tenure systems practiced have made it difficult for females' to obtain land for production purposes. Oja et al. (2012) therefore noted that land ownership plays a vital role in determining farm productivity. This is true in the sense that land ownership influences the farmer's morale to undertake land improvement and management programmes to enhance productivity and sustainability. Furthermore, the ownership of land has also been noted to influence farmers' access to loans to enable them acquire productive resources. The impecuniosity of female farmers therefore hinder their capacity to adopt modern agricultural methods to boost their productivity.

2.8.7 Influence of Educational Level on Agricultural Productivity

Agriculture is a science and therefore requires some basic level of education to appreciate the scientific basis of agricultural production. This basic level of education is also crucial in helping farmers make decisive agro entrepreneurial decisions. According to Nwaru (2004), education is the key to unlocking the natural talents and inherent enterprising qualities of farmers. Rad, Ates, Delioglan, Polatoz, and Ozcomlekci, (2010) asserts that education enhances farmers' ability to derive, decode and evaluate vital information for agricultural production. Farmers' ability to interpret instructions on agro chemicals, adopt modern agricultural technologies and make informed decisions on farming operations is dependent on education (Obasi, Henri-Ukoha, Ukewuihe & Chidiebere-Mark, 2013). Formal education improves the skills of farmers and also makes them more responsive to risk taking and change relative to farmers with no formal education (Xaba & Masuku, 2013). Khan and Saeed (2011) found out that tomato farmers education in Northern Pakistan is one of the determinants of their level of productivity and if invested into, can result in increased production and net profits.

2.9 The Concept of Efficiency

The indispensable role played by agricultural productivity in the economies of the developed world is evident in the abundance of supply and affordability of food and fibre (Hughes, 1998). This growth and development has been attributed to the public and private investment made in research in the development of new and more productive technologies (Kuwornu, et al., 2012). To experience such growth and development in the developing world, similar investments need to be undertaken on productivity enhancing technologies. That notwithstanding, not only can advancement in technology alone lead to optimal productivity gains without the efforts of efficiency, Kuwornu et al. (2012) therefore noted efficiency as a vital tool for enhancing productivity growth.

Coelli, Rao, O'Donnell and Battese (2005) noted that the terms, efficiency and productivity are frequently used interchangeably though they are precisely not the same thing. Efficiency is a concept which is concerned with how well productive inputs are utilised, and exerts a consequential effect on productivity. Efficiency is a relative concept which compares the observed and optimal (standard) values of producer's output(s) and input(s) (Coelli et al., 2005; Fried, Lovell & Schmidt, 2008). In mathematical terms efficiency is expressed as:

$$Efficiency = \frac{Actual\ output}{Standard\ output} * 100\% \quad (2)$$

On the other hand, productivity is the ratio of a producer's output(s) to its input(s), where larger values of this ratio are associated with better performance (Coelli et al., 2005; Fried et al., 2008). Productivity is a measure of efficiency because its value is a reflection of how well tasks are undertaken to arrive at particular output levels. Mathematically, the productivity of a producer is expressed as:

$$Productivity = \frac{Output(S)}{Input(S)} \quad (3)$$

Bravo-Ureta and Pinherio (1993) argued that major technological gains have been exhausted across the developing world, thus resulting in attention on productivity gains been geared towards a more efficient use of existing resources (technology). Omonona, Egbetokum and Akanbi (2010) also noted that in order to increase agricultural output in a cost effective manner, it is imperative to improve the efficiency of farmers rather than introduce new technologies. Smallholder farmers in the developing world like Africa should thus take the initiative to enhance their productive efficiency so as to achieve food security and improve upon their standards of living through the generation of higher incomes (Van der Merwe, 2012).

Speelman, D'Haese, Buysse and D'Haese (2008) defined efficiency as the global relationship between all outputs and inputs in a production process. The concept of efficiency has been central to economic theory. Optimisation which implies efficiency is prime in the theory of production economics (Abdulai, 2006; Baumol, 1977). Managers thus focus on efficiency as the means of achieving set objectives in the production process (Van der Merwe, 2012). The measurement of efficiency is imperative since it can lead to significant resource savings and also influence positively on the formulation of policy and farm management (Bravo-Ureta & Rieger, 1991). The immerse role of efficiency in enhancing agricultural productivity has been widely recognised, thus resulting in an increase in studies in agricultural production efficiency (Shabu, 2013). Following the pioneering work of Farrell (1957), efficiency refers to the ability of a firm to produce a given level of output at the lowest cost. Efficiency in production can be decomposed into three different measures: technical, allocative and economic efficiency (Farrell, 1957; Speelman, et al., 2008).

2.9.1 Technical Efficiency

The measurement of technical efficiency is often done in terms of quantities, it can either take the input or output orientation (Selamat & Nasir, 2013). The input oriented technical efficiency is focused on reducing inputs to attain a given output level, while the output oriented technical efficiency is geared towards the possibility of expanding output for a given set of input quantities (Kingsly & Selvam, 2013). Farrell (1957) refers to technical efficiency as the ability of a firm to obtain maximum output from a given set of inputs (output oriented measure). In other words, technical efficiency is attained when a firm produces a given amount of output by using the minimum feasible level of inputs (input oriented measure) (Coelli, Rahman & Thirtle, 2002). Technical efficiency is a simplified picture of technological efficiency, which indicates whether a particular production unit (firm) is using the best available technology (Selamat & Nasir, 2013; Van Der Merwe, 2012). In considering the production frontier, technical efficiency shows the ability of a firm to attain the maximum potential output by using a given set of inputs and technology (Aigner, Lovell, & Schmidt, 1977; Van Der Merwe, 2012). Selamat and Nasir (2013) argued that technically efficient firms should have the ability to generate the maximum potential output from a given level of inputs.

Technical efficiency can be decomposed into scale efficiency and pure technical efficiency (Fukuyama, 1993; Speelman et al., 2008). This decomposition would help lend a deep insight into the main causes of inefficiencies (Avkiran, 1999; Sanchez, 2009). Scale efficiency is a measure of the effectiveness of the size of an operating unit capable of maximising average productivity (Coelli, Prasada & Battese, 1998; Van Der Merwe, 2012). Scale efficiency helps in determining the level of operation of firms, whether they are operating at the most productive scale size (MPSS), increasing returns to scale (IRS) or decreasing returns to scale (DRS) (Avkiran, 1999). “Pure technical efficiency measures the proportional reduction in inputs that could be achieved if the firm operated on the variable returns to scale frontier" (Al-Jarrah, 2007, p.22).

2.9.2 Allocative Efficiency

Ellis (1988), defined allocative efficiency as the ability of a firm to adjust inputs and outputs in such a way that the ratio of the marginal product of the inputs equates their market prices. Operationally, allocative efficiency can be defined as the optimal distribution of productive resources (input), taking into account their respective prices in a pure competitive resource market. Allocative efficiency is a means of maximising profit, which chooses the least cost method (in relation to input prices) in generating a given level of output (Omonona, Egbetokum & Akanbi, 2010). However, firms may be maximising profits while allocating inputs at inefficient proportions, given input and output prices (Kumbhakar & Wang, 2006).

The literature on allocative efficiency is scanty, with most empirical studies on agricultural efficiency been geared towards technical efficiency (Haruna, Al-hassan & Sarpong, 2011). The intense focus on technical efficiency at the expense of allocative efficiency limits the returns from production, returns from production would attain optimal levels if allocative efficiency is to be given some attention (Bravo-Ureta & Evenon, 1993). Hensher (2001) argued that the concept of allocative efficiency has an added advantage over technical efficiency in estimating economic efficiency because allocative efficiency is concerned with both the process of producing output and the type and balance of output produced, whereas the concept of technical efficiency only looks at the process of production.

A firm is considered allocative efficient if it is producing a given level of output with the optimal combination of inputs given the prices of inputs (Badunenko, Fritsch & Stephan, 2006; Farrell, 1957; Selamat & Nasir, 2013). The availability of price information is paramount to the computation of allocative efficiency using the traditional approach. Some studies which employed the traditional approach in calculating allocative efficiency include: (Atkinson & Cornwell 1994; Greene, 1997; Kumbhakar, 1991; Kumbhakar & Tsionas, 2005; Oum & Zhang, 1995). Farrell (1957) thus referred to allocative efficiency as price efficiency. Information on input prices are sparely available in practice (Badunenko et al., 2006), thus hindering the use of the traditional approach in computing allocative efficiency. The sparse nature of information on input prices explains why empirical literature on allocative efficiency is sparse despite the usefulness of the concept (allocative efficiency) to economist (Badunenko et al., 2006; Greene, 1997).

However, Badunenko et al. (2006) proposed a new approach in estimating allocative efficiency, which does not require information on input prices, but is rather based on quantities and profits.

2.9.2.1 Measurement of Allocative Efficiency

Allocative efficiency can be estimated by either using the production function approach or the dual approach (Haruna et al, 2011). The duality approach is composed of the profit and cost function approaches. Simultaneity bias is noted to be a problem that befalls the production function approach, thus compelling critics to suggest alternative approaches such as the profit function approach (Haruna et al., 2011). The use of the profit function approach is dependent on cross-sectional variability in the prices of variable inputs (Byerlee, 1987). Haruna et al. (2011) noted that though the profit function approach overcomes the endogeniety problem, it also suffers from the problem of non-inclusion of uncertainty, which results in a breakdown of the model. Haruna et al. (2011) further argued that the profit function approach has also suffers from the difficulty in quantifying family labour and other quasi-fixed inputs. The application of profit function in efficiency analysis in modern agriculture tends to render conflicting results to some extend (Byerlee, 1987).

Many studies have also employed the use of the marginal value product and the average variable cost of inputs to measure allocative efficiency of farmers, these studies have asserted that farmers are inefficient at allocating productive resources (Byerlee, 1987). The marginal value products of various inputs are expected to equate their average variable costs, so as to be allocatively efficient.

2.9.2.2 Recent Studies Estimating Allocative Efficiency in Ghana

Several studies have been carried out in Ghana to estimate allocative efficiency. Some of these studies include the following:

Abdulai (2006), carried out a study to assess resource use efficiency in vegetable production by smallholder farmers in the Kumasi Metropolis of Ghana. The study used the marginal productivity approach for the analysis of allocative efficiency. The study estimated allocative efficiency for land and labour as 0.4767 and 0.4556 respectively. From theory, it is known that, the efficiency coefficient of less than or greater than 1 signifies inefficiency, the results therefore signify inefficient utilisation of the two resources of production. This thus implies that land and labour are over utilised. Over utilisation of land refers to the use of a fixed piece of land all year round for crop production without a fallow period. The author attributed the overutilization of labour to the fact that almost all the operations on a small piece of fixed farm land are carried out manually. In contrast, the use of more labour than required by these small scale vegetable farmers could be as a result of poor managerial skills. Abdulai (2006) also attributed the over utilisation of land to rapid urbanisation and the scarcity of water resources which restrict farmers to a particular piece of land for all year round production. This consequently leading to exhaustion of essential nutrients to support crop growth. The findings from Abdulai's study suggest that vegetable farmers lack the ability to combine productive inputs in the most technically efficient manner to maximise output. To enhance the efficiency of vegetable production in the Kumasi metropolis, there is the need for producers to sharpen their managerial skills. Efficiency of the two resources can be increased by decreasing the amount of their usage, which will consequently result in increased output and net profit.

Tambo and Gbemu (2010) also estimated the resource use efficiency in tomato production in the Dangme West District of Ghana. The results of allocative efficiency in tomato production for seed, land, fertiliser, pesticide, family labour and hired labour are 12.22, 8.75, 3.78, 12.80, -0.25 and 6.98 respectively. Inferring from the allocative efficiency coefficients, it can be realised that all the aforementioned resources (seed, land, fertiliser, pesticide, family labour and hired labour) were inefficiently utilised, since they need to have an allocative efficiency coefficient of 1 in order to be considered efficient. The results further suggest that only family labour was over utilised, thus, a decrease in the in the number of family members working on the farm will enhance optimal allocation and cause productivity to increase and which will in effect also cause output and net profit to increase. Seed, land, fertiliser, pesticide and hired labour were on the other hand underutilised and an increase in their usage is desired to increase productivity, since this will result in revenue maximisation by ensuring that these resources are utilised to the optimum.

The literature on previous studies on allocative efficiency tend to conform with the argument of Kibirige (2008), that farmers in sub-Sahara Africa may be allocating resources (inputs) in inappropriate ways. Kibirige further argued that the inefficiency in resource allocation might be due to scarce information and high illiteracy levels on the part of farmers. Inadequate information has been tagged as a resultant factor of both allocative and technical inefficiencies (Ali & Byerlee, 1991; Byerlee, 1987). Rejesus et al. (1999), noted that complete information is vital to ensuring efficiency, with more complete information about input and product markets resulting in improved allocative efficiency of farmers and greater access to crop management information also leading to increased technical efficiency. Farmers are unable to appropriately combine production technologies and resource due to poor managerial skills coupled with inadequate information on the most appropriate technologies and combinations.

2.9.3 Economic efficiency

The multiplicative interactions of technical and allocative efficiencies constitute economic efficiency (Farrell, 1957; Kalarijan & Shand, 1999; Ng'eno, Lagat, Korir, Ngeno, & Kipsat, 2010). Economic efficiency is the ability of a firm to obtain maximum output from an optimal set of inputs, given their respective prices. The underlying premise of Farrell's 1957 work is that, the removal of technical and allocative inefficiencies is a means of achieving efficient production. Thus, if the goal of enhancing efficiency in production is pursued, it will result in productivity gains and strengthen the potential of developing countries in alleviating poverty and also meeting increasing food needs.

2.10 Conclusion of Literature Review

An extensive review of existing literature reveals that farmers' productivity is influenced by the use agricultural inputs. Hence stressing the need for an efficient and effective input market to ensure that farmers obtain appropriate inputs for production. It was realised that the role of government in supplying agricultural inputs in developing countries like Ghana is very vital, since it helps farmers obtain needed quantities of inputs through subsidy programmes. Literature also found that access to inputs (productive resources) alone cannot enhance optimal productivity levels without efficient application of these inputs.

Literature has further revealed that the marketing of fresh tomato in Ghana can be done through diverse channels and therefore asserting that a particular marketing channel adopted by a farmer has a consequential effect on his/her level of profit. Studies on how efficiently farmers allocate resources in Ghana have indicated that farmers are inefficient at allocating productive resources (inputs). Empirical studies on allocative efficiency in Ghana have revealed that, productive resources (inputs) such as land, labour, fertiliser and seeds among others were either underutilised or over utilised.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section presents the profile of the study area, method of sample selection and technique of data collection. The empirical model that is employed to estimate the determinants of yield is presented in this section. The study adopts the gross margin and Cobb-Douglas production function to estimate profitability and the determinants of yield respectively. The variables employed in the analysis of the Cobb-Douglas model are further defined in this section.

3.2 Profile of the Study Area

3.2.1 Location and Size of Study Area

The Upper East Region constitutes the study area. It lies between latitude $10^0 15'$ and $10^0 10'$N, longitude 0^0 and$1^0 4'$W (MOFA, 2013). The region is bounded east by the Republic of Togo, it is also bounded west by the Upper West Region and north and south by the Republic of Burkina Faso and Northern Region respectively (Ghana Statistical Service (GSS), 2013; MOFA, 2013). The Upper East Region has a total land area of 8,842 square kilometres, thereby constituting 3.7% of Ghana's land area (GSS, 2013; MOFA, 2013).

3.2.2 Vegetation and Drainage

The natural vegetation of the region is that of savannah woodland characterised by short scattered drought resistant trees and grass that gets burnt by bushfires or scorched by the sun during the long dry season (GSS, 2013). A small portion of the northern part of Bawku is characterised by Sudan Savannah vegetation. The topography of the region is predominantly undulating with gentle slopes ranging from 1% to 5% slopes. It is fundamentally drained by the White and Red Volta and Sissili Rivers (MOFA, 2013). Dawadawa, sheanut, baobab and acacia are the most prevalent economic trees in the region.

3.2.3 Climate

The region has a unimodal rainfall pattern, which is erratic in space and duration. The raining season falls between May/June and September/October with the mean annual rainfall of 800mm to 1100mm (GSS, 2013). There is a long period of dry season from November to mid-February, characterised by cold dusty Harmattan winds. Temperature at this period can be as low as 14^0 centigrade at night, but can go to more than 35^0 centigrade during the daytime (GSS, 2013).

3.2.4 Demographic Characteristics

The 2010 population census indicates that the Upper East Region has a population of 1,046,545 persons, thus, constituting 4.2% of Ghana’s population. The region has an annual population growth rate of 1.2%. The census results further indicate the predominance of females relative to males in the region (GSS, 2012). Out of the total population in the region, 48.4% and 51.6% represent males and females, respectively (GSS, 2012). Per the 2010 population census, a majority (51.6%) of the people in the region falls within the economic active range of 15 to 64 years old, thus indicating that if properly utilised can yield significant economic benefits to the region and the nation at large.

3.2.5 Economic Activities

The Upper East Region is largely agrarian. It has been estimated that about 80 percent of the region's economically active population is engaged in agriculture (GSS, 2013; MOFA, 2013). Agriculture has propelled the region's economic status from the poorest to the ninth position among the ten regions in the country (MOFA, 2013). Crop farming, hunting, and animal rearing have been the prevalent economic activities of the people of the region. The agricultural sector has further created some prospects for the industrial sector, as a result of the production of certain commodities like vegetables, cereals, legumes and ruminants in commercial quantities.

The Upper East Region produces about 25% of the country's ruminant needs (Okrah, 2010). The region has two major irrigation schemes which aid the cultivation of vegetables in the dry season (from November to April) and this is further facilitated by some other 172 dams and dugouts scattered over the region (MOFA, 2013). According to the GSS (2013); Okrah (2010), industrial activities in the region are fundamentally low with a cotton ginnery at Pusu-Namogo (near Bolgatanga) been the only operational factory in the region. The Northern Star Tomato Factory at Pwalugu, the GIHOC meat factory at Zuarungu and the rice mills at Bolgatanga are other factories in the region, which are non-operational (GSS, 2013).

3.3 Sources and Type of Data

Primary data were sourced for the study. This consisted of cross-sectional information collected on farmers on the costs and returns associated with the production and marketing of fresh tomatoes in the Upper East Region for the 2013/2014 production season. Secondary data were obtained from ICOUR and MOFA on the management of irrigation lands along the catchment area of Tono and Vea irrigation schemes and the major tomato cultivating communities.

3.4 Preliminary Sampling Activities

Prior to data collection, a preliminary survey was carried out to gain an overview of the study area. Officials from the Ministry of Food and Agriculture (MOFA) were consulted regarding the major tomato growing communities. Heads of vegetable farmer based organisations were also consulted, whose role was enormous in mobilising their members for the exercise.

3.5 Sampling Procedure

The population for this study was constituted by all farmers who produced tomatoes under irrigation for the 2013/2014 cropping season in the three major tomato producing Districts. The Upper East Region was chosen for the study because it plays an enormous role in meeting the country's fresh tomato needs most especially during the period of November to May annually. Most tomato farmers did not cultivate the crop for the 2013/2014 cropping season, due to poor rains which resulted in low water levels at the irrigation dams especially Tono. This limited the supply of water to farmers' fields. Farmers also noted that a decline in the number of producers for 2013/2014 cropping season (dry season) was also due to insufficient market for their tomatoes for the past few years. It was attested that tomato traders usually leave them behind and travel to Burkina Faso for tomatoes. Hence making some of them not to recover their cost of production. This situation often compels them to sell their produce at reduced prices in order to counteract postharvest losses.

Multistage sampling technique was used in selecting respondents for this study. The first stage involved the purposive selection of 3 Districts in the Region based on the intensity of tomato cultivation in these Districts and the availability of well-established irrigation schemes to aid regular supply of water for crop production. The chosen Districts include Kassena Nankana East Municipal (KNEM), Bongo District (BD) and Bolgatanga Municipal. The irrigation schemes are the Tono and Vea in the Kassena Nankana East Municipal and Bongo District respectively. Though the Bolgatanga Municipal has no major irrigation facility, some of its farmers operate within the catchment area of the Vea irrigation facility. Secondly, with the help of Agricultural Extension Agents at the various Districts, 8 communities were purposively sampled based on the intensity of tomato production and proximity to the Tono and Vea irrigation schemes. 3 communities, were chosen from Kassena Nankana East Municipal and Bongo District each. The communities that were selected include Korania, Yogbania and Bonia in the Kassena Nankana East

Municipal, Sumbrungu and Sherigu in the Bolgatanga Municipal and Vea, Nyariga and Alaba in the Bongo District. The third stage employed stratified sampling technique in choosing 10 tomato farmers from each community. The stratification was based on farmers who used motorised pumps for irrigation and non-pump users. The number of respondents was drawn from each stratum in proportion to the relative size of the population size of the stratum. Random sampling technique, which employed the lottery technique was used to select farmers from the various strata. A total of 80 farmers was sampled from the 8 communities using stratified random sampling technique. Out of the total sampled farmers, 41 of them used motorised pumps whereas 39 farmers did not use pumps.

Though some farmer based organisations existed in the study area, farmers did not have definite groups which were solely composed of tomato farmers. For this reason, there were no definite lists of tomato farmers, hence, compelling the research team to compile a list of tomato farmers who cultivated the crop in the 2013/2014 cropping season. Furthermore, the study revealed that farmers who cultivated at the far ends of the irrigation canals employed the use of pumps to enable them adequately meet the water needs of their crops. The list of tomato farmers for each community was then classified into users of motorised pumps for irrigation and non-pump users.

3.6 Method of Data Collection

Data were collected mainly through the administration of semi-structured questionnaire. Observations and key informant interviews were also employed in gathering data. Data were collected electronically through the use of a mobile formatted questionnaire. This process, thus precluded data entry after the survey and also helped in eliminating/minimising data entry errors.

3.7 Method of Data Analysis

3.7.1 Analysis of Profitability of Tomato Production

Gross Margin was employed in the analysis of profitability of tomato production in the Upper East Region. Farming is mostly regarded as a way of life, but not an economic activity, where food production for home consumption form an integral part of its activities (Witte, 2004). In the collection of data for economic analysis, it sometimes becomes quite challenging to valuing inputs such as family labour and outputs related to the home (family) consumption (Norman, Worman, Siebert & Modiakgotla, 1995; Witte, 2004). This therefore poses a hindrance to the computation of overall costs and revenue. In the light of this, the use of overall profit in profitability analysis may render a deceptive picture of the profitability of farm enterprises and consequently misinform policy. Upton (1987) also argued that the use of profit (overall profit) in farm enterprise planning is not recommended, for the reason that fixed cost elements do not vary proportionally to the size of the enterprise. Gross margin analysis is thus regarded as a vital tool for assessing the relative profitability of farm enterprises and enhances effective decision making (Kuhlmann, Shannon, & Casement, 2012). Hence, Gross Margin analysis is employed in this study to evaluate the profitability of irrigated tomato production at dam sites in the study area. Gross margins are computed for users of motorised pumps and non-pumps.

Gross Margin is thus stated to be the difference between gross revenue and variable cost. To aid in the estimation of gross margins, Kraybill and Kidoido (2009) proposed the use of three types of information, and these include farm gate prices, crop output levels, and variable costs per unit of production. For the purpose of this study, the weighted average price of a tonne of tomato was used in place of farm gate price because tomatoes were harvested at different times and also sold at different prices across the season. A Gross Margin pro forma outlined by Kuhlmann et al. (2012) was adapted for this study to help present revenue and variable cost items in a cogent manner, this is illustrated in Table 3.1. The revenue and costs were valued at actual market prices for the 2013/2014 production season. Gross margin is stated as:

$$GM = P_y Y - \sum P_i X_i \quad (4)$$

Where:

GM = Gross margin in Ghana Cedi per hectare.

Y = Quantity of fresh tomato output per hectare.

P_y = weighted average price of a tonne of fresh tomatoes.

P_i = Price for each ith input unit.

X_i = Quantity of input used per hectare for each ith input.

Gross margin (GM) is computed as the difference between the total variable cost of cultivating a hectare of tomatoes and the revenue obtained from a hectare of tomatoes. The revenue is computed as the product of the quantity of fresh tomatoes obtained (Y) in tonnes from a hectare and the weighted average price per tonne (P_y).

Quantity of fresh tomato output per hectare (Y) is computed by summing the quantities of fresh tomatoes produced (in tonnes) divided by the number of cultivated hectares for the 2013/2014 season. The per hectare tomato output (Y) is expressed as:

$$Y = \frac{\sum Q_i}{H_t} \quad (5)$$

Where: Q_i denotes total quantity of tomatoes harvested at a given time; H_t denotes number of hectares cultivated for the season.

Because tomatoes are not usually harvested at once, different quantities are often sold at different prices. Hence, the weighted average price at which fresh tomatoes were sold was calculated and used for the gross margin analysis. Weighted average price of a tonne of fresh tomatoes (P_y) is computed by summing the product of the tonnage prices (W_i) and the quantities (Y_i) of fresh tomatoes sold at various prices divided by the sum of the quantities. Following Kuwornu et al. (2012), the weighted average price of fresh tomatoes per tonne (P_y) is defined as:

$$P_y = \frac{\sum Y_i W_i}{\sum Y_i} \quad (6)$$

Total variable cost (TVC) of cultivating a hectare of tomatoes is computed by summing the products of the quantity of the various inputs (X_i) used and the respective prices (P_i) at which they were purchased. Total variable cost is expressed as:

$$TVC = \sum P_i X_i \quad (7)$$

The absolute prices for the various inputs were used because the prices of inputs were stable across the 2013/2014 cropping season. The variable inputs employed in the cultivation of irrigated tomatoes include seed, fertiliser, weedicide, insecticide, fungicide, ploughing cost, labour and irrigation cost. Farm operations that often require labour include nursing of seedling, land clearing and preparation, transplanting, watering, weeding, staking, application of agro chemical (such as fertiliser, weedicide, fungicide and insecticide), harvesting and marketing. The total cost of a particular input used per hectare is computed as the product of the unit cost of the input and the number of times it was used. Hence, total variable cost is computed by summing the total costs of the various inputs employed in cultivating a hectare of tomatoes.

Table 3.1: Gross Margin Pro Forma

INCOME (REVENUE)			
Item	**Quantity/Hectare (Tonnes)**	**Average Price/Unit (GHS)**	**Total Revenue/Hectare(GHS)**
Average yield per hectare			
EXPENSES (VARIABLE COST) **Item**	**Quantity (Tonnes)/Hectare**	**Average price/ unit (GHS)**	**Total Cost/Hectare (GHS)**
Pool Charges **Seed** **Fertiliser** N.P.K 15 15 15 Sulphate of Ammonia **Other Agro Chemicals** Weedicide Insecticides Fungicides **Water use fee (Irrigation Levy)** **Machinery** Fuel & Oil Repairs &Maintenance **Labour (hired & family)** Land preparation Nursing of plants Watering Application of agro chemicals including fertiliser Weeding Harvesting			

Source: adapted from Kuhlmann et al. (2012)

3.7.2 [1]Analysis of Determinants of Tomato Productivity

In assessing the determinants of tomato yield in the study area, a production function was estimated using farm level data obtained from tomato farmers in the 2013/2014 production season. The study hypothesised that tomato yield depends on the amount of seed, labour, fertiliser, weedicide, insecticide, irrigation cost, farmers years of schooling and farmers access to extension education. A Cobb-Douglas production function was estimated following the work of (Ahmad, Chaudhry & Iqbal, 2002; Battese, Malik & Gill, 1996). Plant population is an important determinant of plant yield (KwaZulu-Natal Department of Agriculture and Environmental Affairs, 2003), thus making it a vital variable in productivity analysis. Due to poor agronomic practices in the study area, tomato farmers had varied plant spacing within fields and did not also assess the germination rate of their seeds, thus making it difficult to appropriately compute for plant population. The difficulty in computing plant population for various fields in the study area, compelled this study to use the quantity of seeds planted as a proxy for plant population. Table 3.2 gives the definition and measurement of the variables used in the Cobb-Douglas model. The production function which is considered for tomato farmers in the Upper East Region is implicitly expressed as:

$$Y= AX_1^{\beta 1} AX_2^{\beta 2} \ldots \ldots \ldots AX_n^{\beta n} V \quad (8)$$

[1] Cost of irrigation is used as a proxy for quantity of water used (moisture content) for tomato production because the water for irrigation was charged on per unit of area cultivated, thus making it difficult to quantify the quantity of water that goes into one's farm.

The function is thus expressed in the linearized form as:

$$LnY = LnA + \sum_{i=1}^{n} \beta_i ln\, X_i + \varepsilon \qquad (9)$$

From equation (8) the empirical model can be explicitly expressed as:

$$ln(yield) = \beta_0 + \beta_1 ln(seed) + \beta_2 ln(labour) + \beta_3 ln(fertiliser) + \beta_4 Lnweedicide + \beta_5 ln(insecticide) + \beta_6 ln(irrigationcost) + \beta_7 ln(Lneducation) + \beta_8 extension + e_i \qquad (10)$$

Table 3.2: Description of Variables used in the Cobb-Douglas Production Function

Variable	Definition	Measurement of Variables	A priori Expectations
Ln(yield)	Natural log of the amount of tomato produced per hectare.	Tonnes	+
Ln(seed)	Natural log of the amount of seeds used per hectare.	grams	+/-
Ln(labour)	Natural log of the quantity of family and hired labour used per hectare.	(8-hour man-days)	+/-
Ln(fertiliser)	Natural log of the amount of synthetic fertiliser used (NPK and sulphate of ammonia) per hectare.	Kilograms	+
Ln(weedicide)	Natural log of the amount of weedicides used in the production of tomato per hectare.	Litres	+
Ln(insecticide)	Natural log of the amount of insecticides used per hectare.	Litres	+
Ln(irrigationcost)	Natural log of the amount of money spent on irrigation per hectare.	Ghana cedi	+/-

Ln(education)	Natural log of number of years spent in school.	Year	+
extension	This is based on whether a farmer has received any extension visits at the time of production.	Dummy: 1=received extension visits 0 = otherwise	+

$\beta_1, \beta_2, \beta_3 \ldots\ldots \beta_7$ are elasticities, where $\beta_8$is a coefficient

β_0 constant factor

A positive β will be found on variables associated with increased yield, while a negative β will be found when a variable is associated with a loss in yield.

$e_i =$ error term measuring variation in tomato output unaccounted for by the independent variables.

3.7.3 Description of Variable used in the Cobb-Douglas Production Function

Variables employed in the estimation of the production function include yield, seed, labour, fertiliser, weedicide, insecticide, irrigation cost, years of schooling and access to extension education.

Yield: is measured as the quantity of fresh tomatoes produced per hectare for the 2013/2014 cropping season. Farmers were guided to help them estimate the number of 80 kg boxes of tomatoes they harvested for the 2013/2014 season, after which the total weight of tomatoes harvested was divided by the number of hectares cultivated to obtain the per hectare yield. The weight is then converted from kilograms to tonnes. In the study area, farmers sold their fresh tomatoes either in 80 kg boxes or in other containers such as basins and buckets. The 80 kg box was used as the standardised measure of weight of tomatoes.

The 80 kg box equivalence of tomatoes that were sold in other containers was computed and used for the analysis.

Seed: this represents the quantity of tomato seeds planted per hectare of land. This was measured in grams. The quantity of seeds planted was computed by either finding the quantity of purchased seeds or stored seeds planted. In cases where both purchased and stored seeds were used, their total was computed.

Labour: this is composed of the total quantity of family and hired labour units employed in carrying out all manual actives to produce a hectare of tomatoes. Labour was measured in 8 hour man-days. The manual labour activities stretched from nursing of seedlings to marketing. Virtually all farm activities are time bound, therefore, this requires the timely execution of activities to attain optimal yield. Labour was only hired when family labour was not sufficient to execute a particular farm operation within the required time.

Fertiliser: this refers to the total quantity of inorganic fertiliser (NPK 15.15.15 and Sulphate of Ammonia) applied in the production of a hectare of tomatoes. These two types of fertilisers were used by virtually all tomato farmers for the 2013/2014 cropping season. An increase in the use of fertiliser was expected to increase the productivity of tomatoes, since it replenishes lost nutrients emanating from crop production.

Weedicide: this took into account the amount of the various weedicides applied to cultivate a hectare of tomatoes. The quantity of weedicides used was dependent on the type of weed control method employed coupled with the type and growth level of weeds. Weeds compete with crops for nutrients, water, and sunlight and also tend to harbour crop pests and diseases. Effective weed control is expected to increase yield. When chemical weed control is practiced, an increase in the use of weedicides is expected to increase the productivity of tomato, since this was to reduce the completion between tomatoes and weeds for nutrients by keeping the fields free of weeds.

Insecticide: this also refers to the total quantity of insecticides and fungicides used to cultivate a hectare of tomatoes. It was realised that farmers referred to both insecticides and fungicides as "DDT" and applied them as a mixture. For the purpose of this study, both agro chemicals (insecticides and fungicides) were classified as insecticides. It is expected that an increase in the use of insecticides will enhance the control of insect pests and fungal diseases.

Cost of irrigation: this took into account the total cost of irrigation incurred in cultivating a hectare of tomatoes. It is expected that efficient water supply will help maintain soil moisture content suitable for the growth and development of tomatoes. An increase in the irrigation cost is expected to increase water delivery onto farmers' fields to aid crop growth.

Education: this refers to the total number of years a farmer spent in school. This was incorporated in the model because an increase in farmers' years of schooling was expected to influence their ability to adopt appropriate production technologies to increase his/her productive efficiency.

Extension: this refers to whether a farmer has received any visits from extension officers or not. Extension education is noted to improve the managerial abilities and skills of farmers, thus extension officers are expected to transmit new and more innovative farming techniques to farmers. Extension visits have the potential of increasing farmers' knowledge of the appropriate practices to pursue in order to influence yield. Extension is a dummy variable. A value of one is scored for farmers who received extension visits for the 2013/2014 cropping season and zero otherwise.

3.7.4 Regression Diagnostics

Stata statistical software package version 12.0 was employed to analyse the Cobb-Douglas model. To ascertain that the model was appropriately specified and that it does not violate the assumptions of the Ordinary Least Squares (OLS), a couple of regression diagnostics were conducted on the model. In this regard, multicollinearity problem in the model was tested for using the Variance Inflation Factor (VIF) test. Multicollinearity refers to a situation in which there is a high correlation between explanatory variables in a multiple regression model (Andren, 2007). The VIF test provided an index that measured how much the variance of an estimated regression coefficient is increased as a result of collinearity. The VIF is expressed as:

$$VIF = \frac{1}{1-R_j^2} \tag{11}$$

Where: R_j^2 represents the coefficient of determination of the regression equation.

In analysing multicollinearity, the magnitude of the Variance Inflation Factor (VIF) was taken into consideration. Econometric theory has posited a general rule of thumb that states that, the values of the Variance Inflation Factor (VIF) exceeding 4 induce the need for further investigation, while Variance Inflation Factor (VIF) values greater than 10 signify the existence of high multicollinearity. The results obtained from the test of the Cobb-Douglas model employed in this study indicated that multicollinearity was not a problem.

Heteroskedasticity is a problem that usually befalls cross-sectional data and thus tends to give erroneous conclusions. In this regard the Breusch-Pagan/Cook Weisberg test was ran on the Cobb-Douglas model and it was found out that heteroskedasticity was absent. This notwithstanding, the model was further checked for adequacy to ensure that no needed variables were omitted. As a consequence, the Ramsey Regression Equation Specification Error Test (RESET) test was conducted and the findings indicated that the model was correctly specified.

3.7.5 Analysis of Allocative Efficiency

To accomplish the goal of profit maximisation and efficient use of resources in a perfectly competitive market, a farmer must utilise production inputs (resources) at the level where marginal value product is equal to the marginal factor cost (Kabir Miah, Ashraful Alam, & Rahman, 2006). The efficiency of a resource is the ratio of the marginal value product of the resource to its marginal factor cost. Following Fasasi (2006); Goni, Mohammed and Baba (2007); Stephen, Mshelia and Kwaga (2004); Tambo and Gbemu, (2010), the allocative efficiency of a resource is given as;

$$r = \frac{MVP}{MFC} \quad (12)$$

Where:

r = Allocative Efficiency Coefficient

MVP = Marginal Value Product

MFC = Marginal Factor Cost

Following Tambo and Gbemu (2010), the decision rule for allocative efficiency analysis is, if:

r = 1; resource is being used efficiently.

r >1; resource is underutilisation and increased utilisation would increase output. r <1; resource is over utilised and reduction in its usage would lead to maximization of profit.

The Cobb-Douglas regression coefficients represent output elasticities which are used to compute the marginal physical product (MPP). When equation (9) is differentiated with respect to the various inputs ($X_i \ldots \ldots X_n$) it gives Betas ($\beta_i \ldots \ldots \beta_n$)

$$\frac{\partial LnY}{\partial LnX} = \left[\frac{\frac{1}{Y}*\partial Y}{\frac{1}{X}*\partial X}\right] = \left[\frac{\frac{X}{Y}*\partial Y}{\partial X}\right] = \beta_i \quad (13)$$

Using the coefficient from equation (9) (that is the estimated coefficients from the Cobb-Douglas model), the marginal physical product (MPP) of the i^{th} factor X is then computed as:

$$MPP_i = \frac{\partial Y}{\partial X} = \beta_i \frac{\bar{Y}}{X_i} \quad (14)$$

Where:

$\bar{Y}$ =Geometric mean of tomato output. This was computed using the quantities of tomatoes (in tonnes) obtained by farmers for cultivating a hectare of land for the 2013/2014 cropping season.

$X_i =$ Geometric mean of input i. This is also computed from the quantities of input i employed in cultivating a hectare of tomatoes for the 2013/2014 cropping season.

The Marginal Value Product of input i is thus obtained by multiplying the marginal physical product (MPP_i) by the weighted output price(P_y):

$$MVP_i = MPP_i * P_y \tag{15}$$

Where P_y is the tonnage price of fresh tomatoes, it is the weighted average price for selling a tonne of tomatoes in the Upper East Region for the 2013/2014 cropping season.

Following Grazhdaninova and Lerman (2004), farmers are price takers in the resource (input) market, thus the marginal cost of resource (input) i approximates the price of factor i, P_{x_i}. Thus, Marginal Factor Cost (MFC) = P_{x_i}= where P_{x_i} = unit price of input x_i. The prices at which the various inputs were sold in the study area for the 2013/2014 cropping season were stable throughout the season.

In cases where the inputs (resources) were inefficiently allocated, the required adjustments in marginal value product were estimated to ensure that r = 1 or MVP = MFC. Following Gani and Omonona (2009); Mijindadi (1980), the relative percentage adjustment in the marginal value product (MVP) of each input required to attain optimal input allocation was computed as:

$$D = \left(1 - \frac{MFC}{MVP}\right) * 100 \quad \text{or,} \tag{16}$$

$D = (1 - r^{-1}) * 100$ or

$D = \left(\frac{1}{1} - \frac{1}{r}\right) * 100$

Where:

D = absolute value of percentage change in MVP of each input (resource) (Gani & Omonona, 2009; Mijindadi, 1980)

MVP = marginal value product

MFC = marginal factor cost

r = allocative efficiency coefficient

3.8 Summary of Methodology

A total number of 80 irrigated tomato farmers were sampled for this study through a multistage sampling technique. Notwithstanding the numerous methods for estimating enterprise profitability, gross margin analysis was employed to assess the profitability of irrigated tomato production in the Upper East Region. The Cobb-Douglas production function was also adopted to estimate the factors that affect the productivity of irrigated tomatoes. The allocative efficiency of inputs (resources) used by irrigated tomato farmers was estimated using the marginal value product and marginal factor cost of the various resources.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results and discussions of the study with respect to socioeconomic characteristics of the respondents, and the gross margin analysis of irrigated tomato production in the Upper East Region. The analyses of the determinants of yield and allocative efficiency of factor inputs are also presented in this chapter.

4.2 Socioeconomic Characteristics of Farmers

4.2.1 Age Distribution of Farmers

Table 4.1 describes the age distribution of farmers in the study area. It could be deduced from the results that the age of tomato farmers ranged between 21 and 74 years, with 21 and 74 being the minimum and maximum ages respectively. In general, a vast majority (95%) of the farmers sampled were within the economically active age group of 15-64 years, with the remaining 5% falling within the elderly dependent group of 65 years and above. The Kassena Nankana East Municipal has 96.67% of its sampled farmers falling within the potentially active age cohort, while that of the Bongo District and Bolgatanga Municipal been 93.34% and 95.00% respectively. The results further showed that 3.33%, 6.66% and 5% denote the proportion of farmers within the aged dependent cohort for Kassena Nankana East Municipal, Bongo District and Bolgatanga Municipal respectively. Based on the de factor definition of population, World Bank (2015b) categorised the ages between 15 and 64 as the world's potential economically active age class. The observed trend in the age distribution of this study could serve as an incentive to enhance productivity, since there would be a sufficient energetic labour force to carry out physically demanding activities. Hence, if farmers are supported with the appropriate input resources, they can play an enormous role in eradicating poverty via increased production.

Table 4.1 Age Distribution of Farmers

	Kassena Nankana East Municipal		Bongo District		Bolgatanga Municipal		Total	
Age	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
15-24	1	3.33	-	-	-	-	1	1.25
25-34	4	13.33	5	16.67	6	30.00	15	18.75
35-44	12	40.00	7	23.34	6	30.00	25	31.25
45-54	10	33.33	12	40.00	5	25.00	27	33.75
55-64	2	6.67	4	13.33	2	10.00	8	10.00
65-74	1	3.33	2	6.66	1	5.00	4	5.00
Total	30	100	30	100	20	100	80	100

Source: Field Survey, February 2015

4.2.2 Gender of Farmers

Table 4.2 gives a clear description of the sex of tomato farmers in the study area. The results from the study assert that tomato farming in the study area is male dominated with a total of 71.25% males and 28.75% females. The Kassena Nankana East Municipal has a greater proportion of females (43.33%) farming tomatoes. Bolgatanga Municipal has the least (10%) number of females that are into tomato production. The observed pattern in the sex distribution is not surprising and could thus be attributed to the difficulty in females' accessibility or ownership of land in the area of study. Conjunctively, a study by Clottey et al. (2009) also attributed the low participation of females in tomato farming to the riskiness and capital intensive nature of the business. In spite of the fact that, fewer females were engaged in tomato farming, they are often actively involved in the production process by helping their husbands on their fields.

Table 4.2 Gender Distribution of farmers

	Kassena Nankana District		Bongo District		Bolgatanga Municipal		Total	
Gender	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
Male	17	56.67	22	73.33	18	90	57	71.25
Female	13	43.33	8	26.67	2	10	23	28.75
Total	30	100	30	100	20	100	80	100

Source: Field Survey, February 2015

4.2.3 Household Members Working at the Farm

The amount of household members available to work on the farm has a direct influence on the size and structure of a farm enterprise, management techniques and management performance (International Livestock Centre for Africa (ILCA), 1990). Larger households often have the capacity to expand their plant sizes and thus benefit from economies of scale (ILCA, 1990). The foregoing analysis thus suggests that, the availability of household members (family labour) to carry out farm activities at various stages of the production cycle is essential in assessing the production capacity and profitability of small scale farmers. This is because small scale farmers often use household labour (family labour) for virtually all farm operations except in cases where it is not sufficient to ensure timely execution of some activities. Hence the availability of family labour can serve as an incentive to expand ones production and increase profitability. Inferring from the field survey results depicted in Table 4.3, there seems not to be much difference in the average family labour units employed by farmers across the three districts, with Bolgatanga municipal having an average of 2.45 household labour units whilst leaving Kassena Nankana East Municipal and Bongo District with 1.93 and 1.90 household labour units respectively. The results further suggest that in totality, an average of 2.04 household labour units were employed on 0.69 hectares per farmer. Considering the average land size (0.69 hectares) and the average family labour unit of 2.04, the observed quantity of family labour in the study area is thus an incentive for farmers because half of the labour requirements is obtained from a cheap source. Comparing the average farm size and family labour, it appears that farmers would solely depend on family labour for most of their operations.

Table 4.3 Household Members Working at the Farm

	Kassena Nankana East Municipal		Bongo District		Bolgatanga Municipal		Total	
Household Members working at farm	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
	1.93	1.66	1.90	1.35	2.45	1.96	2.05	1.63

Source: Field Survey, February 2015

4.2.4 Educational Status of Farmers

Table 4.4 gives an overview of the level of farmers' education in the various districts. Information gathered from the field shows that the level of education of farmers in the study area is generally low. Kassena Nankana East municipal recorded the lowest level of education with 63.33% of the sampled farmers spending between 0 and 3 years at school. The majority (60%) of the sampled farmers in Bolgatanga municipal spent between 0 and 3 years at school. The sampled farmers in Bongo district also had more than half (53.33) of the sampled population spending between 0 and 3 years at school. This low level of education might affect farmers' decision making negatively since they might lack the required intellect to read and understand, adopt and adapt improved production techniques to enhance productivity. Appleton and Balihuta (1996) argued that a minimum of 4 years of schooling is needed for literacy and numeracy to be functionally attained and impact on the farm output of Ugandan farmers. The level of farmers' education is expected to influence their production decision making, with higher educational levels correlating with higher value yield and more commercially oriented agriculture (Minot, Epprecht, Anh, & Trung, 2006).

Table 4.4 Educational Status of farmers

	Kassena Nankana East Municipal		Bongo District		Bolgatanga Municipal		Total	
Years of schooling	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
0-3	19	63.33	16	53.33	12	60.00	47	58.75
4-7	5	16.67	9	30.00	2	10.00	16	20.00
8-11	4	13.33	3	10.00	4	20.00	11	13.75
12 >	2	6.67	2	6.67	2	10.00	6	7.50
Total	30	100	30	100	20	100	80	100

Source: Field Survey, February 2015

4.2.5 Farmers' Source of Finance

Results in Table 4.5 show that, the majority (93.75%) of the sampled farmers financed their production from their proceeds, while 5% and 1.25% financed their production from loans from relatives and financial institutions respectively. The results from the three districts indicate that only 5% of farmers representing 1 farmer in the Bolgatanga Municipal obtained funding from a financial institution to finance his production. Furthermore, 6.67%, 3.33% and 5.00% of farmers in the Kassena Nankana East Municipal, Bongo district and Bolgatanga Municipal respectively financed their production from relatives/friends. The observed trend in financing farm operations therefore asserts that it is very difficult if not impossible for smallholder farmers to access credit from financial institutions to expand their production. Dinye (2013), attributed the inaccessibility of credit by farmers from financial institutions to lack of collateral security and the unwillingness of some farmers to take loans as a result of high interest charges and short repayment periods.

Table 4.5 Source of Finance

	Kassena Nankana East Municipal		Bongo District		Bolgatanga Municipal		Total	
Source	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
Self-Finance	28	93.33	29	96.67	18	90.00	75	93.75
Loan from Relative	2	6.67	1	3.33	1	5.00	4	5.00
Loan from Financial Institution	0	0	0	0	1	5.00	1	1.25
Total	30	100	30	100	20	100	80	100

Source: Field Survey, February 2015

4.2.6 Years of Experience in Tomato Production

The farmers sampled for the study have a total average of 9.19 years of tomato farming experience with a standard deviation of 6.68. The modal year of farming experience is 4.00 years. The results therefore suggest that farmers at least have some mid-level of experience to help them adjust to uncertainties in their production process to enhance profitability. Table 4.6 gives an overview of farmers' years of experience in tomato production.

Table 4.6 Farmers' Years of Experience

Years of Experience	Kassena Nankana East Municipal	Bongo District	Bolgatanga Municipal	Total
Mean	9.07	10.97	6.70	9.19
Standard Deviation	7.04	6.88	5.12	6.68
Mode	7	4	4	4

Source: Field Survey, February 2015

4.2.7 Land Acquisition among Farmers

Information gathered during the key informant interview with ICOUR officials indicated that the land within the operational areas of Tono and Vea Irrigation Schemes is owned by the state. Land around the catchment area of these schemes (Tono and Vea Irrigation Projects) was reallocated to farmers with priority given to farmers who were displaced during the construction of the dam infrastructure. The reapportioned plots became the permanent properties of the various farm families. A farmer/farm family forfeits his/their apportioned plot of land only when he/they consistently fail to fulfil the major obligation of paying the annual levy to ICOUR. However, none of the sampled farmers lost their land for the study period (2013/2014 cropping season). Interaction with farmers during the survey also revealed that during the 2013/2014 dry season, they (farmers) paid GHS 99.84 per hectare as a facility user fee to ICOUR. When a farmer do not intent cultivating his plot for a particular year, he often leases it to a prospective user.

Farmers who cultivate around dam sites other than Tono and Vea, acquired land through inheritance and/or rent. The study also found out that farmers who were sampled from

Sherigu in the Bolgatanga Municipal paid GHS 2.00 per 80 kilogram box of tomatoes harvested to the management of the local irrigation scheme as fees for the usage of the irrigation facilities. Farmer in Sherigu used a community dam that was established by the Bolgatanga Municipal Assembly, in collaboration with other NGOs as noted by farmers. This facility was managed by the Water Users Association established in the community. Based on the average number of boxes harvested per hectare, it was therefore estimated that a levy of GHS 107.21 was paid by farmers in the Bolgatanga municipal for the usage the irrigation facilities.

Inferring from Table 4.7, it could be deduced that majority of farmers across the three sampled districts acquired land for dry irrigation farming through inheritance. A relatively small proportion of farmers rented land in the study area. Bolgatanga Municipal recorded 88.33% for farmers who inherited land, whilst Bongo District and Kassena Nankana East Municipal also recorded 63.33% and 85.00% respectively. In total, 76.25% of farmers inherited land for production against 23.75% who obtained land through rent.

Table 4.7 Mode of Land Acquisition among Farmers

	Type of land Acquisition	Family/ own land (inheritance)	Leased/rented	Total
Kassena Nankana East Municipal	Freq.	25	5	30
	Percentage (%)	83.33	16.67	100
Bongo District	Freq.	19	11	30
	Percentage (%)	63.33	36.67	100
Bolgatanga Municipal	Freq.	17	3	20
	Percentage (%)	85.00	15.00	100
Total	Freq.	61	19	80
	Percentage (%)	73.25	23.75	100

Source: Field Survey, February 2015

4.2.8 Distribution of Farmers Based on Land Holding

Table 4.8 shows the distribution of farmers based on land holding. The average size of land cultivated to tomato in the study area is 0.69 hectares with a standard deviation of 1.04. 1.00 hectares also represent the modal size of land cultivated to tomatoes. This observation thus suggests that tomato production in the study area is mainly under small scale since the average size of land cultivated to tomatoes is below 2 hectares. According to Thepa (2009), small scale farming refers to the cultivation of a plot size (total land holding) of less than 2 hectares and also depending on household members for most of the farm labour needs.

Table 4.8 Farm Holding of Farmers

Farm Holding (Hectare)	Kassena Nankana District	Bongo District	Bolgatanga Municipal	Total
Mean	0.82	0.62	0.60	0.69
Standard Deviation	1.57	0.61	0.32	1.04
Mode	1.00	0.50	1.00	1.00

Source: Field Survey, February 2015

4.2.9 Tomato Varieties Cultivated in the Study Area

Table 4.9 gives a quick overview of the varieties of tomato cultivated in the Upper East Region. The results for the three districts, thus signify that, the majority (98.20%) of the farmers cultivated improved tomato varieties, whereas 1.8% of the farmers cultivated local varieties. Among the varieties cultivated across the three districts, "No name" recorded a cultivation percentage of 37.84 representing the most cultivated variety, while Beefsteak and Nirvana had 0.90 percentages each of cultivation rate, denoting the least cultivated varieties. The results from the sampled farmers also indicate that some of the farmers cultivated more than one tomato variety for the 2013/2014 dry season. Following Robinson and Kolavalli (2010a), No Name tomato variety is believed to be a species of the Pectomech variety. The Upper East Regional Office of MoFA, could not verify whether no name variety is another species of Pectomech variety. The seeds of no name usually come in plain sachets with no inscription.

[2]Table 4.9 Tomato Varieties Cultivated by Farmers for 2013/2014 season

	Kassena Nankana East Municipal		Bongo District		Bolgatanga Municipal		Total	
Variety	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
Pectomech	6	18.18	21	38.89	6	25.00	33	29.73
Tropimech	1	3.03	1	1.85	5	20.83	7	6.31
"No Name"	26	78.79	6	11.11	10	41.67	42	37.84
Roma	-	-	14	25.93	1	4.17	15	13.51
Beefsteak	-	-	-	-	1	4.17	1	0.90
Nirvana	-	-	-	-	1	4.17	1	0.90
5-Picture	-	-	10	18.52	-	-	10	9.01
Local	-	-	2	3.70	-	-	2	1.80
Total	33	100	54	100	24	100	111	100

Source: Author's computation from Field Survey, February 2015

4.2.10 Farmer Access to Extension Education

Extension education is expected to increase farmers' yield. Extension education has the potential to increase farmers managerial skills which will help them combine productive inputs appropriately and also ensure the execution of agronomic practices appropriately. Table 4.10 presents farmers' access to extension education in the study area. The results

[2] The total frequency recorded for farmers cultivating the various tomato varieties across the three districts is greater than the total number of farmers sampled for the study because some of the farmers cultivate more than one variety.

indicate that 25% of the total number of farmers sampled for the study had access to extension education, whereas 75% did not gain access to extension education. This therefore suggests that, most tomato farmers might lack the proper managerial knowledge and skills to efficiently carry out production activities to optimise yield.

Table 4.10. Farmers Access to Extension Education

	Kassena Nankana District		Bongo District		Bolgatanga Municipal		Total	
	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)	Freq.	Percentage (%)
Access to extension education	9	30.00	5	16.67	6	30.00	20	25.00
No access to extension education	21	70.00	25	83.33	14	70.00	60	75.00
Total	30	100	30	100	20	100	80	100

Source: Author's computation from Field Survey, February 2015

4.3 Analysis of profitability of production

Gross Margin Analysis

Gross margin was employed to assess the profitability of irrigated tomato production in the study area. Gross margin was calculated using the arithmetic means of the required input components. The results are presented in a more disaggregated manner so as to clearly illustrate the contribution of various input factors to costs. The Gross Margin for the tomato enterprise is calculated on a per hectare basis for irrigated production involving the use of pumps and irrigated production without pumps. Gross revenue is made up of the product of the average quantity of marketable tomatoes per hectare (in tonnes) and the weighted average price per unit (tonne). Marketable tomatoes were made up of the sum of tomatoes sold, given as gifts, consumed by family and stored as seeds. Furthermore, total variable cost was computed by summing all the expenses which varied with varying levels of production. An average revenue of GHS 4,663.54 was recorded per hectare of tomato produced, GHS 2,453.68 and GHS 3,022.01 were also recorded as the respective variable cost for farmers who did not use pumps and those who used pumps for irrigation. Farmers who did not use irrigation pumps recorded an average gross margin of GHS 2,209.86 per hectare whilst GHS 1,641.53 represents that of farmers who used irrigation pumps. The gross margin percentage of the total variable cost of tomato farmers who did not use pumps was estimated to be 90%, whereas that of farmers who used pumps was 54%. This implies that for every Cedi invested, gross margins of GHS 0.90 and GHS 0.54 accrued to farmers who did not use pumps and those who used pumps respectively. The gross margin results indicate that, an irrigated tomato production system which does not use pumps for irrigation is more profitable than the production system which uses irrigation pumps. The disparity in total variable costs is attributed to the extra cost incurred in lifting water into fields that are at the far ends of irrigation canals. To further ascertain the profitability level of the two systems, the study went a further mile to compute the income/expenditure ratio of farmers, which was found to be 1.90 and 1.54 for farmers who did not use pumps and farmers who used pumps respectively. This shows that for every Cedi invested in irrigated tomato production, a gross revenue of 1.90 and 1.54 will accrue to farmers who used pumps and those who did non-pumps users respectively. The foregoing analysis further buttresses the fact that dependence on gravitational irrigation (non-pump users) is cost effective relative to the system which uses pumps to supplement the gravitational system of irrigation. Table 4.11 shows gross margin results.

Table 4.11. Tomato Enterprise Gross Margin Analysis

INCOME (REVENUE)			
Item	**Quantity (Tonnes)/Hectare**	**Average price/unit (GHS)**	**Total Revenue (GHS)**
Quantity per hectare	66.88boxes	69.73	4663.54
	5.35tonnes	871.69	4663.54

Variable Costs			
Item	**Average Quantity/Hectare**	**Average cost/unit (GHS)**	**Total cost/Hectare (GHS)**
Ploughing	1 hectare	160.62	160.62
Seeds	5.16 (516.00gm)	44.62	230.24
Chemicals			
Fertilizer (NPK & Sulphate of Ammonia)	9.74 (487.00kg)	96.25	935.48
Weedicides	3.44 (3.44 Litres)	17.52	60.27
Insecticides& Fungicides	5.92tins (5.92 Litres)	17.62	104.31
Labour			
Family Labour	33.76 man-days	9.65	325.78
Hired Labour	47.38 man-days	9.65	457.22
Machinery			
Fuel and Maintenance of water pumps	1hectare	568.33	568.33

Water use fee (Irrigation levy)			
Charge on the usage of Irrigation facility (ICOUR/Local dam authority)	1hectare	103.02	103.02
Total variable cost of production			2376.94* 2945.27**
Transportation to market		76.74	76.74
Total variable cost			2453.68* 3022.01**

Gross Margin per Hectare of tomato cultivated	
Gross margin	2209.86* 1641.53**
Gross margin percentage of total variable cost	90 54

Source: Author's computation from Field Survey, February 2015

* = denotes the result for farmer who did not use pumps for irrigation

** = denotes the result for farmers who used pumps for irrigation

Income-expenditure ratio for farmers who did not use irrigation pumps $=\frac{4663.54}{2453.68}=1.90$

Income-expenditure ratio for farmers who used irrigation pumps $=\frac{4663.54}{3022.01}=1.54$

4.4 Analysis of Determinants of Tomato Yield

Table 4.12 presents the regression results. From the regression results, the amount of labour, the quantity of fertiliser, the quantity of weedicide, irrigation cost and access to extension education were found to significantly affect the yield of tomatoes cultivated under irrigation in the study area. Since yield is an indicator of productivity, the results therefore signify that the productivity of tomato production in the study area is dependent on the quantity of labour, fertiliser, weedicide, irrigation cost and access to extension education. The amount of labour and cost of irrigation are significant at 5%, whereas, quantity of fertiliser, quantity of weedicide and access to extension education are significant at 1%. The Adjusted R-squared value of 0.48 implies that 48% of the variation in tomato yield is explained by the model. The F-statistic value of 10.30 is significant at 1%. This implies that the independent variables have a joint effect on tomato yield.

Except access to extension education, the estimated parameters in the Cobb-Douglas model represent the output elasticities of the various inputs. The scale elasticity of production was estimated to be 0.69. This implies that tomato yield will increase by 0.69% from a 1% increase in all input factors. The less than a proportionate change in yield resulting from a percentage change in all inputs, therefore, means that, output is increasing at a decreasing state. The scale elasticity value of 0.69 further signifies the existence of decreasing returns to scale, and thus suggest that tomato farmers are operating in the second (rational) stage of the production frontier, where their marginal product is decreasing but is still positive.

The elasticity value of labour indicates that if the amount of hours spent on the field increase by 1%, the yield of tomatoes will increase by 0.20%. This trend in labour requirement is in accordance with a priori expectation that an increase in labour will lead to increase in yield. This may be attributed to the fact that tomato farming is labour intensive and thus requires high labour to appropriately execute production operations.

A 1% increase in fertiliser application increases tomato yield by 0.31%. The positive relation between fertiliser usage and yield could be due to the fact that continued application of fertiliser will replenish lost soil nutrients and provide the needed nutrients for crop growth and development. Judging from the fact that an increase in the application of fertiliser will help supply needed nutrients to maximise yield, the positive effect is justified.

The results further reveal that 1% increase in the application of weedicide increases yield by 0.15%. This conforms to the a priori expectation of a positive effect. Weedicides are needed to control weeds to prevent competition among crops and weeds for nutrients. Thus, an increase in the use of weedicides suggests frequent weed control on the field, which is essential in ensuring efficient crop growth, development and yield. Hence the positive value for weedicide is justified.

An increase in the cost of irrigation by 1% will result in a 0.13% increase in yield. The positive effect of irrigation cost emphasizes the significance of irrigation in meeting moisture requirement to help attain desired yield. The results also suggest that farmers at the far ends of the irrigation canals need to spend some extra money to fuel machines to enable them to lift water onto their fields to meet the recommended moisture needs of their tomato crops.

The effect of education is not significant, and this might be due to inadequate years spent at school to influence yield. A 1% increase in years of schooling increases tomato yield by 0.05%. The positive effect of education on yield conforms to a priori expectation.

When the quantity of seeds increases by 1%, tomato yield will decrease by 0.11%. An increase in the quantity of seeds planted per hectare can result in plant population exceeding recommended threshold. The negative relationship between seed and yield, though not desired, it conforms to a priori expectation. This is because over population of tomato plants in the field could lead to high competition for nutrients by tomato plants, and hence, cause yield to diminish. Information gathered from tomato farmers further suggest that farmer were planting an average of 512 grams of seed, this indicates that, the level seed application exceeds MOFA's recommended range of 300 grams to 450 grams per hectare. Though plant population is a significant determinant of yield, its indicator (seed) is not significant.

An increase in the number of extension visits by 1 extension officer will increase tomato yield by 0.40%. This implies that, farmers who receive extension visits will produce more yield of tomato relative to farmers who do not receive any visits. Hence, justifying the need for extension education to strengthen farmers' technical knowledge on tomato production.

Table 4.12. Analysis of Determinants of Tomato Output.

Dependent variable: LnYield

Variable	Coefficient	Standard error	t-Statistic	Probability (P>|t|)
(Constant)	-1.4776	.6621	-2.23	0.029
Lnseed	-.1059	.1066	-0.99	0.324
Lnlabour	.1999**	.0851	2.35	0.022
Lnfertiliser	.3063***	.0974	3.14	0.002
Lnweedicide	.1500***	.0540	2.78	0.007
Lninsecticide	-.0351	.0690	-0.51	0.612
Lnirrigation	.1309**	.0578	2.26	0.027
Lneducation	.0469	.0397	1.18	0.242
Extension	.3993***	.0925	4.32	0.000
R^2 = 0.5372 Adj. R^2 = 0.4851	Prob > F = 0.0000 F-value = 10.30	Standard error = .34417		

** Significant at 5% *** Significant at 1%

4.5 Analysis of Resource Use efficiency

To determine the allocative efficiency of tomato farmers, the study made use of the Cobb-Douglass results presented in Table 4.12 together with the geometric mean values of the various variables employed in the model. The geometric mean values of the variables are estimated and presented in Table 4.13. The marginal physical products (MPP) of some inputs were computed using the coefficients from the Cobb-Douglas regression function and the geometric means of the variables. The marginal physical product (MPP) is then multiplied by the weighted average price of a tonne of fresh tomatoes in order to obtain the marginal value product (MVP). The marginal value product (MVP) is then compared with the marginal factor cost (MFC) (which is the market prices of the inputs). The weighted average price of a tonne of fresh tomatoes used in the analysis is GHS 871.69. When the allocative efficiency coefficient of a resource (input) is less than 1, it means that the input is over utilised. Also, when the coefficient is greater than 1, it implies that the input is underutilised. Allocative efficiency coefficient of 1 justifies that a particular input is efficiently allocated.

Table 4.13. Geometric means of Input Variables and Yield.

Variable	Geometric mean
Yield	4.8144 tonnes
Seed	472.5675 grams
Labour	92.3547 man-days
Fertiliser	420.2364 kilogrammes
Weedicide	2.5996 litres
Insecticide	4.7950 litres
Irrigation cost	209.1824 GHS

Source: Author's computation

The marginal physical product of seed is -0.0011, implying that any additional seeds planted results in the reduction of tomato output by 0.0011tonnes per hectare. The quantity of seeds also has an allocative efficiency coefficient (r) of -2.13, meaning that the seeds are over utilised and a reduction in their usage will optimise profit.

The marginal physical product of labour is 0.0104, this means that any additional hour spent on the farm to produce tomatoes will add 0.0104 tonnes to tomato yield. The results further reveal that labour has an allocative efficiency coefficient of 0.94, meaning that labour is over utilised and thus needs to decrease to increase profit.

Fertiliser has a marginal physical product of 0.0035. This means that for any additional kilogram of fertiliser applied to the field, 0.0035 tonnes of tomato are added to the total output produced per hectare. The marginal value product of fertiliser also exceeds the marginal factor cost, thus resulting in an allocative efficiency value of 1.58. This implies that fertiliser is underutilised and thus needs to be increased to enhance profitability and this corroborates Tambo and Gbemu (2010), who studied the resource-use efficiency in tomato production in the Dangme West District of Ghana and reported underutilisation of fertiliser. The usage of fertiliser below the recommended levels is justified by the lack of government subsidy on fertiliser for the year 2014. Farmers attested to this fact by indicating that they were unable to acquire appropriate quantities of fertilizer due to the high cost of the product. The study revealed that, farmers applied an average of 487 kilograms of fertiliser per hectare, this is below MOFA (2011) recommendation of about 600 kilograms (average sum of NPK, potassium nitrate and sulphate of ammonia fertilisers).

The marginal physical product of Weedicide is 0.2778, implying that an additional litre of weedicide adds 0.2778 tonnes to the total output of tomatoes produced per hectare.

Weedicide also has an allocative efficiency coefficient of 13.82. This means that weedicide is underutilised and an increase in its usage will ensure efficient allocation, which will consequently lead to profit maximisation. The underutilisation of weedicide might be as a result of the availability of cheap manual labour to control weeds on tomato fields.

Insecticide has a marginal physical product of -0.0352. This implies that for any additional litre of insecticide put into tomato production, total output reduces by 0.0352 tonnes. The allocative efficiency coefficient of -1.74 implies that insecticide is over utilised and a reduction in its usage will result in efficiency. Farmers may be over applying insecticide on their fields so as to help them control insect pest on their fields. Some farmers noted that insect pests are becoming resistant to the insecticides they use, this thus suggest that, farmers are increasing their frequency of spraying control pests.

Irrigation cost, which is a proxy for moisture content has a marginal physical product of 0.0030, implying that for any additional unit of water applied to the field, 0.0030 tonnes of tomatoes are added to the total output. Furthermore, irrigation cost has an allocative efficiency coefficient of 0.01. This means that water is over used and needs to be reduced to ensure efficiency.

Inferring from the results of resource use efficiency as shown in Table 4.14, the use of seed, insecticide and irrigation cost were found to have allocative coefficients of less than 1. This implies that an increase in the use of these inputs decreases total output (profit).

This therefore suggests that these resources (inputs) are over utilised and a reduction in their use will enhance efficiency. The over application of productive resource by farmers might be due to poor managerial skills on the part of farmers, with regards to the best agronomic practises to pursue in order to maximise yield.

The results further indicate that fertiliser and weedicide have allocative efficiency coefficients greater than 1. This suggests that these resources are underutilised and an increase in their usage will result in efficient allocation which will in turn lead to increased profitability. Kuwornu et al. (2012) is of the view that tomato farmers in Ghana are reluctant to commit more resources into production because of the fear of incurring losses due to expected fall in output price. This might be the reason why tomato farmers in the Upper East region are not willing to use optimum quantities of some inputs. The underutilisation of these inputs might also be due to unavailability of sufficient capital to purchase appropriate quantities of these inputs.

Table 4.14. Analysis of Resource-use Efficiency in Tomato production in the Upper East Region.

Resource/Input	Coefficient (β_i)	Marginal Physical Product (MPP)	Marginal Value Product (MVP) (GH¢)	Marginal Factor Cost (MFC) (GH¢)	Allocative efficiency coefficient (r) MVP/MFC
Seed	-0.1059	-0.0011	-0.96	0.45	-2.13
Labour	0.1999	0.0104	9.07	9.65	0.94
Fertiliser	0.3063	0.0035	3.05	1.93	1.58
Weedicide	0.1500	0.2778	242.16	17.52	13.82
Insecticide	-0.0351	-0.0352	-30.68	17.62	-1.74
Irrigation	0.1309	0.0030	2.62	209.18	0.01

Source: Author's computation

Table 4.15 illustrates the percentage adjustment in marginal value products for optimum utilization of inputs. For an input to be optimally utilised, the marginal value product is required to equate the marginal factor cost (MVP = MFC). The adjustment values are presented in absolute terms. For optimum allocation of inputs, the use of seed, labour, insecticide and water (irrigation cost) are expected to decrease by 146.95%, 6.38%, 157.47% and 9,900% respectively. On the other hand, the use of fertiliser and weedicide is required to increase by 36.71% and 92.76% respectively, so as to optimise allocation.

Table 4.15. Required Adjustment in the Marginal Value Product (MVP) (in percentage) for Optimal Resource Allocation of Variable Inputs.

Variable	Percentage Adjustment Required (D)
Seed	146.95
Labour	6.38
Fertiliser	36.71
Weedicide	92.76
Insecticide	157.47
Irrigation cost	9,900.00

Source: Author's computation

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

Tomato is a major cultivated vegetable crop in the Upper East Region, which therefore creates employment for most farm families during the dry season. Its production also augments the income of farmers and ensures efficient utilisation of the labour force during the dry season. Efficiency is a key concept in production economics, which must be understood and applied to enhance productivity gains. The study mainly analysed the allocative efficiency of tomato production under the irrigated system of farming in the Upper East Region. The study specifically analysed the profitability of irrigated tomato production. Factors affecting productive output in tomato production were also analysed. The study further assessed how efficiently productive inputs (resources) for tomato production under the irrigated system are utilised.

Data were obtained through the administration of a semi-structured questionnaire. Data were sourced from both primary and secondary sources. Primary data were collected on tomato production for the 2013/2014 production season through personal interviews with tomato farmers in the study area. The study targeted tomato farmers who use public irrigation schemes, mainly, Tono and Vea irrigation schemes. Farmers at the far end of these canals used motorised pumps to lift water to their fields. MOFA, ICOUR, websites and publications constituted the secondary sources of data. A total of 80 tomato farmers were interviewed. Excel and Stata computer software programmes were made use of in analysing the data. Data were analysed using both descriptive and inferential statistics. The information gathered from the study are presented below.

The socioeconomic characteristics of farmers revealed that 95% of tomato farmers in the study area are within the economically active age cohort. This is thus an advantage to intensify the commercialised production to maximise profits. This goal can be realised through the initiation and/or intensification of farmer support programmes like subsidies on productive inputs. Since this will assist farmers to recover their production cost and also help them to compete with farmers internationally.

Tomato production was found to be largely on a small scale with an average cultivated land area of 0.69 hectares and also employing an average of 2.04 permanent family labour units. This situation could be due to insufficient funding and market for tomato output. Farmers noted that they hardly get funding from financial institutions to support their production. Since it is expected that, access to funding would help them expand their production and enjoy economies of scale. Farmers sampled for the study further argued that tomato traders often leave them behind and travel to Burkina Faso for tomatoes, they claim this makes them suffer postharvest losses. For the risk of not getting ready market some farmers tend to cultivate on a small scale such that in critical cases of bad market, they can undertake their own market operations by taking the fruit to the market for retail. These factors could be the possible causes of the small scale of production.

Farmers across the three sampled districts also attained an average of 4.55 years of experience in tomato production, thus suggesting that farmers might have some minimum experience to enable them adjust to diverse production conditions and improved innovative techniques of farming to enhance profitability.

A small proportion of the sampled farmers had contact with extension officers during the production period. Only 25% of the sampled farmers received visits from extension officers, while 75% of farmers did not receive any visit. The low level of extension contact might be due to a deficit in the number of extension officers in the country. This situation impacts negatively on the transmission of technical knowledge to farmers, and thus cause them to be inefficient in their operations.

The profitability analysis of irrigated tomato production revealed that farmers are making an average income of GHS 4,663.54 per hectare. The total variable cost of farmers, however, differed with respect to users of irrigation pumps and non-pump users. The total variable cost of production per hectare for non-pump users is GHS 2,453.68 whereas the total variable cost per hectare for pump users is GHS 3,022.01. On the average, farmers who did not use irrigation pumps recorded a gross margin of GHS 2,209.86 per hectare, while users of pumps recorded an average gross margin GHS 1,641.53 per hectare. The results from the study further indicate that, the irrigated tomato production system which uses irrigation pumps is less profitable than production system which does not use irrigation pumps. This has been backed by the gross income-expenditure ratios (returns on investment) of 1.90 and 1.54 for non-pump users and pump users respectively. The difference in the total variable cost is accounted for by the extra money invested in fuelling and maintaining irrigation pumps.

Analysis of determinants of tomato yield (output per hectare) using a Cobb-Douglas production function revealed that fertiliser, weedicide and access to extension education were significant at 1% level of significance and they all showed a positive relationship with yield. More so, labour, fertiliser and irrigation cost were significant at 5% level of significance, which also exhibited a positive relationship with yield. The scale elasticity value of 0.69 obtained from the sum of all output elasticities indicates that, farmers are experiencing decreasing returns to scale. This suggest that some fixed input(s) (such as land) is/are overstretched and is then causing marginal product to diminish at a positive rate following the addition of any unit of variable input. This therefore suggests the need for farmers to reduce the use of some of their variable inputs in order to enhance efficiency and optimise profit.

On the overall, the resources employed in irrigated tomato production in the study area were not efficiently allocated. In spite of the inefficiency in allocation, it was realised that labour was the most efficiently allocated input, since it is the resource which needs the least adjustment in the marginal value product (of about 6.38%) in order to be optimally allocated. Irrigation cost is also the least appropriately allocated input because it needs the greatest adjustment in the marginal value product (about 9,900%) to be optimally allocated.

5.2 Recommendations

Inefficiency in the allocation of resources (inputs) suggests an existence of knowledge gap on the part of farmers on the appropriate combination of resources and agronomic practices viable to ensuring optimal results (output). Field demonstration programmes should be strengthened to expose farmers to the practical results of using the appropriate quantities of inputs and adherence to good field (agronomic) practices. This will help enhance the efficiency of farmers because tomato farmers that attained extension education were found to produce more yield relative to farmers who did not access extension education. Thus, the intensification of farmer field demonstrations by research institutions like the Council for Scientific and Industrial Research (CSIR), the Savannah Agriculture Research Institute (SARI) and the Ministry of Food and Agriculture (MOFA) will result in the adoption of practices that can improve production efficiency and enhance productivity growth and consequently improve farmers' standards of living.

Following MOFA (2013), the achievable yield of tomato in Ghana is estimated to stand at 15 tonnes per hectare, whereas the results from this study indicate that irrigated production of the crop (tomato) in the Upper East Region is below the expected yield. An average yield of 5.35 tonnes per hectare was recorded by farmers, with 3.95 tonnes, representing the modal yield per hectare. It is therefore believed that the yield gap may be as a result of high average cost of production. This study, therefore, recommends that agricultural producer-oriented policies that are aimed at ensuring minimum cost of production by farmers should be implemented and pursued. For this reason, government should ensure that the fertiliser subsidy programme becomes efficient and sustainable, in order to help farmers acquire factor inputs at prices that will help them reduce their costs of production. The programme should be extended to cover other agricultural production inputs.

Following the resource use efficiency results in Table 4.14, the inefficiency figures on fertiliser and weedicide suggest underutilisation of these resources. It is therefore recommended that, tomato farmers should increase the use of fertiliser and weedicide by 36.71%, and 92.76% respectively to enhance efficiency and optimise profit. On the other hand, seed, labour, insecticide and irrigation cost were overused in the production process. To attain allocative efficiency in the application of seed, labour, insecticide and irrigation cost (water), tomato farmers should decrease the use of these resources by 146.95%, 6.38% 157.47% and 9,900% respectively. This suggests the need for farmers to be encouraged to enforce good farm management practices in order to achieve desired results from their efforts. Hence the need for MOFA to initiate and/or promote farmers' extension education through the various media in the country, since this will help commensurate for the deficit in extension officers in the country. This will help enhance tomato farmers' efficiency because an increase is extension education was found to have a positive effect on yield.

Despite the fact that tomato yields are below expectation, farmers sampled for this study exhibited a great interest in the production of tomato but could not apportion more land to its production. Farmers attributed the small scale of their production to inadequate finance to purchase required inputs to expand production. The gross returns on investment values of 1.90 and 1.54 for non-pump users and pump users is an indication that tomato production in the study area might be profitable. Government should therefore exploit this advantage to help cater for the nation's tomato needs and also generate foreign exchange through export. Government should also provide financial support for small scale tomato farmers' through programmes like the Ghana Agricultural Sector Investment Programme (GASIP) and the Rural Enterprises Programme (REP). These support programmes should have an innate policy that mandates beneficiaries to co-finance their production, since this will help to eliminate unserious farmers who might be risk averse and only interested in extorting public funds.

Farmers operating at the far ends of the irrigation canals incurred higher costs in accessing water relative to their counterparts who are closer to the irrigation canals. This is because tomato farmers at the far ends of the canals used motorised pump to lift water into their fields whereas farmers closer to the canals did not. This has resulted in a variation in their costs and profit levels. This is because farmers far away from the canals paid a fixed water use levy and also invested in the fuelling and maintenance of their irrigation pumps, whereas farmers closer to the canals paid the fixed water use levy as their only cost of irrigation. In order for tomato farmers operating under the two systems to match their total variable costs, this study recommends that, farmers far away from the irrigation canals should come together (by forming associations) and negotiate with the irrigation authorities to discount the irrigation levy for farmers at the far ends the irrigation canals. This should be done for farmers cultivating beyond certain recommended metres from the canals, at which efficient water distribution unattained.

REFERENCES

Abankwah, V., Fialor, S.S., & Aidoo, R. (2013). Performance efficiency of the liberalised agricultural pesticide marketing system in Ghana. *Journal of Agricultural Economics and Development, 2*(8), 305-316. Retrieved from http://academeresearchjournals.org/journal/jaed

Abdulai, A. (2006). *Resource use efficiency in vegetable production: The case of smallholder farmers in the Kumasi metropolis* (Master's thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.). Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/17048/17048.pdf?sequence=1

Abebe, T. (2011). The impact of input and output market development intervention of the IPMS Project: The case of Meiso Woreda, Oromiya national regional state, Ethiopia. (Master's thesis, Haramaya University). Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/12514/FinalThesis_TihitinaAbebe.pdf?sequence=1

Adazabra, A. N., Appiah – Kubi, K., & Bamford, S. A. (2013). Multielement analysis of fresh tomatoes produced at the Tono irrigation scheme by instrumental neutron activation analysis. *International Journal of Scientific & Engineering Research, 4*(8), 880-884.

Adebooye, O. C., Ajadi, S. O., & Fagbohun, A. B. (2006). An accurate mathematical formula for estimating plant population in a four dimensional field of sole crop. *Journal of Agronomy, 5*(2), 289-292. DOI: 10.3923/ja.2006.289.292

Adubofuor, J. E., Amankwah, A., Arthur, B. S. and Appiah, F. (2010). Comparative study related to physico-chemical properties and sensory qualities of tomato juice and cocktail juice produced from oranges, tomatoes and carrots. *African Journal of Food Science, 4*(7), 427 – 433.

Adu-Dapaah, H., & Oppong-Konadu, K. (2002). Tomato production in four major tomato-growing districts in Ghana: Farming practices and production constraints. *Ghana Journal of Agricultural Science, 35,* 11-22.

Afolabi, O. I., Adegbite, D. A., Ashaolu, O. F., & Akinbode, S. O. (2013). Profitability and resource-use efficiency in poultry egg farming in Ogun State, Nigeria. *African Journal of Business Management, 7*(16), 1536-1540. DOI: 10.5897/AJBM2013.6955

Ahmad, M., Chaudhry, G. M., & Iqbal, M. (2002). Wheat productivity, efficiency, and sustainability: A stochastic production frontier analysis. *The Pakistan Development Review*, *41*(4), 643–663. Retrieved from http://mpra.ub.uni-muenchen.de/3672/

Aigner, D. J., Lovell, C., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics, 6(*1)*,* 21–38.

Ali, M. & Byerlee, D. (1991). Economic efficiency of small farmers in a changing world: A survey of recent evidence. *Journal of International Development*, *l3* (1), 1-27.

Al-Jarrah, I. M. (2007). The use of DEA in measuring efficiency in Arabian banking. *Banks and Bank Systems, 2*(4)

Amikuzuno, J., & Ihle, R. (2010, September). *Seasonal asymmetric price transmission in Ghanaian tomato markets: Adapting Johansen's estimation method.* Poster Presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa.

Anderson, J. R., (2007). *Agricultural advisory services*. Background Paper for World Development Report 2008, Agriculture for Development, World Bank. Washington, DC.

Anderson, J. R., & Feder, G. (2007). Agricultural extension. In Evenson, R. E and Pingali, P. (eds.), *Agricultural Development: Farmers, Farm Production and Farm Markets*, *Handbook of Economics Vol. 3. Elsevier,* Amsterdam, pp. 2343–2378.

Andren, T. (2007). *Econometrics*. USA: Thomas Andren and Ventus Publishing Aps.

Appleton, S., & Balihuta, A. (1996). Education and agricultural productivity: evidence from Uganda. *Journal of International Development*, *8*, 415-444.

Ariga, J., & Jayne, T.S. (2009). *Private sector responses to public investments and policy reforms. The case of fertilizer and maize market development in Kenya.* (IFPRI Discussion Paper 00921). Washington, DC: International Food and Policy Research Institute

Asare-Bediako, E., Showemimo, F. A., Buah, J. N., & Ushawu, Y. (2007). Tomato production constraints at Bontanga irrigation project in the Northern Region of Ghana. *Journal of Applied Sciences, 7*, 459-461.

Atkinson, S. E. & Cornwell, C. (1994). Parametric estimation of technical and allocative inefficiency with panel data. *International Economic Review, 35*(1)*,* 231-243.

Attoh, C., Martey, E., Kwadzo, G.T.M., Etwire, P. M., & Wiredu, A. N. (2014). Can farmers receive their expected seasonal tomato price in Ghana? A probit regression analysis. *Sustainable Agriculture Research, 3*(2), 16-23. DOI:10.5539/sar.v3n2p16

Avkiran, N. K. (1999, December). Decomposing the technical efficiency of trading banks in the deregulated period. In *12th Australasian Finance and Banking Conference* (pp. 16-17).

Badunenko, O., Fritsch, M., & Stephan, A. (2006). *Allocative efficiency measurement revisited – Do we really need input prices?* (DIW Berlin Discussion Paper 591). Berlin: German Institute for Economic Research.

Baltzer, K., & Hanser, H. (2011). *Agricultural input subsidies in Sub-Saharan Africa*. (Evaluation study 2011/2) Ministry of Foreign Affairs of Denmark. Retrieved from http://www.oecd.org/derec/49231998.pdf

Banful, A. B. (2010). *Old problems in the new solutions? Politically motivated allocation of program benefits and the "new" fertilizer subsidies*. (IFPRI Discussion Paper 01002).

Barbosa-Cánovas, G. V., Fernández-Molina, J. J., Alzamora, S. M., Tapia, M. S., López-Malo, A., & Chanes, J. W. (2003). *Handling and preservation of fruits and vegetables by combined methods for rural areas. Technical manual.* (Food and

Agriculture Organization (FAO) Bulletin 149). Retrieved from http://www.fao.org/docrep/005/y4358e/y4358e06.htm

Battese, G. E., Malik, S. J. & Gill, M. A. (1996). An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics, 47*, 37–49.

Baumol, W. J. (1977). *Economic theory and operations analysis* (4th ed). Englewood Cliffs, NJ: Prentice-Hall.

Berthe, A. (2015). *Extension and Advisory Services Rural extension service for Agricultural Transformation*. (Background Technical Paper). Retrieved from http://www.afdb.org/fileadmin/uploads/afdb/Documents/Events/DakAgri2015/Extension_and_Advisory_Services_Rural_Extension_Services_for_Agricultural_Transformation.pdf

Birkhaeuser, D., Evenson, R. E. & Feder, G. (1991). The economic impact of agricultural extension: A review. *Economic Development and Cultural Change, 39* (3), 607–640.

Bortey, H. M. (2010). *Quality of farmer-saved tomato (Lycopersicum esculentum mill.) Seeds and its effect on fruit yield in Ghana* (Unpublished master's dissertation). Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Bratianu, P., & Schwontkowski, D. (2013). *How to benefit from everyday herbs - A beginner's guide to homemade natural herbal remedies for common ailments and good health.* Simple Media works.

Bravo-Ureta, B. E., & Evenson, R. (1993). Efficiency in agricultural production: The case of peasant farmers in Eastern Paraguay. *Elsevier Journal of Agricultural Economics, 10* (1994), 27-37.

Bravo-Ureta, B. E., & Pinherio, A. E. (1993). Efficiency analysis of developing country agriculture: A review of the frontier function literature. *Agriculture and Resource Economics Review, 22*(1), 88-101.

Bravo-Ureta, B. E., & Rieger, I. (1991). Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. *American Journal of Agricultural Economics*, *73*(2), 421 -428.

Bull, D. (1989). A growing problem: Pesticide and the third world poor farmers. New York, NY: Oxford Press.

Byerlee, D. (1987). *Maintaining the momentum in post-green revolution agriculture: A micro-level perspective from Asia*. (MSU International Development Paper No. 10). University of Michigan.

Camelo, A. F. L. (2004). *Manual for the preparation and sale of fruits and vegetables from field to market.* (FAO Agricultural Services Bulletin 151). Rome, Italy.

Chauvin, N. D., Mulangu, F., & Porto, G. (2012). *Food production and consumption trends in Sub-Saharan Africa: Prospects for the transformation of the agricultural sector.* (United Nations Development Programme (UNDP) Working Paper No. 011). Regional Bureau for Africa.

Clottey, V. A., Karbo, N., & Gyasi, K. O. (2009). The tomato industry in Northern Ghana: production constraints and strategies to improve competiveness. *African Journal of Food, Agriculture, Nutrition and Development, 9*(6), 1436-1451. Retrieved from http://dx.doi.org/10.4314/ajfand.v9i6.46265

Coelli, T., Prasada, D., & Battese, G. E. (1998). *An introduction to efficiency and productivity analysis.* Kluwer Academic Publishers.

Coelli, T., Rahman, S., & Thirtle, C. (2002). Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: A non-parametric approach. *Journal of Agricultural Economics, 53*(3), 607-626.

Coelli, T., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis* (2nd ed). USA: Springer Science & Business Media.

Crawford, E. W., Jayne, T. S., & Kelly, V. A. (2006). *Alternative approaches for promoting fertilizer use in Africa*. (Agriculture and Rural Development Discussion Paper 22). Washington D.C.: World Bank.

Crawford, E., Kelly, V., Jayne, T. S. & Howard, J. (2003). Input use and market development in Sub-Saharan Africa: An overview. *Elsevier Journal of Food Policy, 28*(4)*,* 277–419.

Dinye, R. D. (2013). Irrigated agriculture and poverty reduction in Kassena Nankana district in the Upper-East Region, Ghana. *Journal of Science and Technology, 33*(2), 59-72.

Dlova, M. R., Fraser, G. C., & Belete, A. (2004). Factors affecting the success of farmers in the Hertzog Agricultural Cooperative in the central Eastern Cape. *Fort Hare Papers*, *13*, 21 - 33.

Dzisah, S. K. (2013). Growth, Yield and Quality of Heat Tolerant Tomato as Influenced by Different Watering Regimes. (Master's thesis, University of Ghana, Legon).

Ellis, F. (1988). *Peasant farm households and agrarian development*. Cambridge: Cambridge University press.

Ellis, W. O., Olympio, N. S., Mensah, E. P., Adu-Amankwa, A., Tetteh, Y. (1998). Postharvest problems of tomato production in Ghana - Field studies of some selected major growing areas in Ghana. *Journal of the Ghana science association, 1*(1), 55-59.

Ercan, N. & Vural, H. (1994). The effects of low temperatures on fruit set of tomatoes. *Acta Horticulturae*, 366, 65-72.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society, 120*(3)*,* 253-290. DOI: 10.1016/S0377-2217(01)00022-4

Fasasi, A.R. (2006). Resource use efficiency in yam production in Ondo State, Nigeria. *Agricultural Journal, 1* (2), 36-40.

Food and Agriculture Organisation (FAO) (2005). Fertiliser use by crop in Ghana.

Food and Agriculture Organisation (FAO) (2010). Gender and land rights – Understanding complexities, adjusting policies; Economic and social perspectives, FAO Policy Brief, Rome: FAO.

Food and Agriculture Organisation (FAO) (2015a). FAOSTAT. Retrieved from http://faostat3.fao.org/download/Q/QC/E

Food and Agriculture Organisation (FAO) (2015b). Crop Water Information: Tomato. Retrieved from http://www.fao.org/nr/water/cropinfo_tomato.html

Food and Agriculture Organisation (FAO) (2015c). FAOSTAT. http://faostat3.fao.org/download/FB/BC/E

Freeman, H. A., & Kaguongo, W. (2003). Fertilizer market liberalization and private retail trade in Kenya. *Food Policy, Elsevier, 28*(5–6), 505–518.

Fried, H. O., Lovell, C. A. K., & Schmidt, S. S. (2008). *The measurement of productive efficiency and productivity growth*. USA: Oxford University Press.

Fulginiti, L. E., & Perrin, R. K. (1998). Agricultural productivity in developing countries. *Agricultural Economics*, *17,* 45-51. Retrieved from http://digitalcommons.unl.edu/ageconfacpub/17

Fukuyama, H. (1993). Technical and scale efficiency of Japanese commercial banks: A non-parametric approach. *Applied Economics*, 25, 1101–1112.

Gani, B. S., & Omonona, B. T. (2009). Resource use efficiency among small - scale irrigated maize producers in Northern Taraba State of Nigeria. *Journal of Human Ecology, 28*(2), 113-119

Gast, K. L. B. (1994). Harvest Maturity Indicators for Fruits and Vegetables. Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Gent, M. P. N., & Ma, Y. Z. (1998). Diurnal temperature variation of the root and shoot affects yield of greenhouse tomato. *Horticultural Science, 33*, 47–51.

Ghana Statistical Service (GSS) (2013). 2010 Population and housing census: Regional analytical report Upper East Region.

Goni, M., Mohammed, S., & Baba, B. A. (2007). Analysis of resource-use efficiency in rice production in the Lake Chad area of Borno State, Nigeria. *Journal of Sustainable Development in Agriculture & Environment, 3*, 31-37.

Government of Ghana (2016). *The launch of the fertiliser subsidy programme and the way forward*. Retrieved from http://ghana.gov.gh/index.php/media-center/features/1153-the-launch-of-the-agric-fertilizer-subsidy-programme-and-the-way-forward

Grazhdaninova, M., & Lerman, Z. (2004). *Allocative and technical efficiency of coporate farms in Russia.* (Discussion paper No. 12.04).

Greene, W. (1997). Frontier production functions. In: M. H. Pesaran, & P. Schmidt (eds.), *Handbook of Applied Econometrics*, *vol. 2. Blackwell Publishers,* (pp. 81-166).

Ha, T. M. (2015). Agronomic requirements and production methods of tomatoes in the Red River Delta of Vietnam. *Journal of Tropical Crop Science, 2*(1), 33-38.

Hammer, K. C., Stewart, U.S., & Matrone, G. (1943). Thiamine determination by the fungus growth method and its comparison with other methods. *Food Res*, 8, 444-451

Hanson, P., Chen, J. T., Kuo, C. G., Morris, R.., & Opena, R. T. (2001). *Tomato Production.* http://www.avrdc.org/ /tomato/production/0 LC 4climate.html [24 August 2009].

Haruna, I. (2012). An analysis of the constraints in the tomato value chain. *International Journal of Business and Management Tomorrow,* 2 (10), 1-8.

Haruna, I., Al-hassan, R., & Sarpong, D. B. (2011). An analysis of allocative efficiency of shea butter processing methods in the northern region of Ghana. *Journal of Development and Agricultural Economics, 3*(4), 165-173. Retrieved from http://www.academicjournals.org/JDAE

Haruna, I., Nkegbe, P. K., & Ustarz, Y. (2012). Structure, conduct and performance of tomato marketing in Ghana. *Journal of Economics and Sustainable Development, 3*(10), 156-163.

Heisey, P. W., & Mwangi, W. (1996). *Fertiliser use and maize production in Sub-Saharan Africa.* (CIMMYT Economics working Paper 96-01). Mexico D.F.

Hensher, M. (2001). *Financing health systems through efficiency gains*. CMH working paper series. Paper no. WG3: 2.

Heuvelink, E. (2005). Developmental processes. In E. Heuvelink, (2005), *Tomatoes, CABI Publishing*, *London, UK,* (pp. 53-83).

Hofstrand, D. (2009). *Understanding profitability*. Iowa State University Extension. Retrieved from http://www.extension.iastate.edu/agdm/wholefarm/pdf/c3-24.pdf

Horna, D., Smale, M., & Falck-Zepeda, J. (2006). Assessing the potential economic impact of genetically modified crops in Ghana: Tomato, garden egg, cabbage and in processing tomatoes. *Scientia Horticulturae,* 27, 189-198.

Hughes, G. (1998). *Agricultural productivity and farm structure in the Czech Republic.* EU FAIR Project Agricultural Implications of CEEC Accession to the EU. Working Paper Series, (Working Paper 2/7). Wye College, University of London.

International Fertiliser Development Centre (IFDC) (2012). *Ghana fertilizer assessment.* Retrieved from https://ifdcorg.files.wordpress.com/2015/04/ghana-fertilizer-assessment.pdf

International Food Policy and Research Institute (IFPRI) (2010). *The economic importance of* agriculture *for sustainable development and poverty reduction*: *A case study of Ghana.* Washington, DC: IFPRI.

International Livestock Centre for Africa (ILCA) (1990). *Livestock systems research manual.* (Working Paper 1, Vol. 1). ILCA, Addis Ababa, Ethiopia. 287

International Livestock Research Institute (ILRI) (1995). *Livestock Policy Analysis*. (ILRI Training Manual 2). ILRI, Nairobi, Kenya, pp. 264.

Kabir Miah, M. A, Ashraful Alam, A. K. M., & Rahman, A. H. M. A. (2006). Impact of agricultural credit on MV Boro rice cultivation in Bangladesh. *Journal of Agriculture & Rural Development, 4*(1&2), 161-168.

Kabutha, C. (1999, November). *The Importance of Gender in Agricultural Policies, Resource Access and Human Nutrition.* A Paper Presented to a Seminar on Agricultural Policy, Resource Access and Nutritional Outcomes, Addis Ababa, Ethiopia. Retrieved from http://knowledgecentre.drwa.org.in/green/pdffiles/basissem9911_panel4b.pdf

Kahan, D. (2013). *Market-oriented farming: An overview*. Food and Agriculture Organization of the United Nations, Rome Italy.

Kalirajan, K. P., & Shand, R. T. (1999). Frontier production functions and technical efficiency measures. *Journal of Economic Surveys*, *13*(2), 149 –172.

Khan, H., & Saeed, I. (2011, December). *Management of technical, allocative and economic efficiency of tomato farms in northern Pakistan*. International Conference on Management, Economic and Social Sciences (ICMESS) Bangkok.

Kibirige, D. (2008). *Analysis of the impact of the agricultural productivity enhancement program on the technical and allocative efficiency of maize farmers in Masindi district* (Master's thesis, Makerere University Kampala, Uganda). http://mak.ac.ug/documents/Makfiles/theses/KIBIRIGE%20DOUGLAS.pdf

Kingsly, P. S., & Selvam, M. (2013). Technical, pure technical and scale efficiency of new and old private sector banks in India – Data envelopment analysis. Retrieved from http://ssrn.com/abstract=2304840

Kotler, P. (1991). *Marketing management: Analysis, planning, implementation, and control* (7th ed). Englewood Cliffs, NJ: Prentice Hall.

Krausova, M., & Banful, A. B. (2010). *Overview of the agricultural input sector in Ghana.* (IFPRI Discussion Paper No. 01024).

Kraybill, D., & Kidoido, M. (2009). *Analysis of relative profitability of key Ugandan agricultural enterprises by agricultural production zone.* (Uganda Strategy Support Program (USSP) Background Paper no. USSP 04).

Kuhlmann, P., Shannon, D., & Casement, D. (2012). *Farm gross margin and enterprise planning guide 2012: A gross margin template for crop and livestock enterprises*. Produced by Rural Solutions, South Australia. Retrieved from http://www.grdc.com.au/Resources/~/media/764C6717986D4F878F155CD365BB5050.ashx

Kumbhakar, S. C. (1991): The measurement and decomposition of cost-inefficiency: The translog cost system. *Oxford Economic Papers, New Series, 43*(4), 667-683.

Kumbhakar, S. C., & Tsionas, E. G. (2005). Measuring technical and allocative inefficiency in the translog cost system: A Bayesian approach. *Journal of Econometrics, 126*, 355–384.

Kumbhakar, S. C., & Wang, H. (2006). Pitfalls in the estimation of a cost function that ignores allocative inefficiency: A Monte Carlo analysis. *Journal of Econometrics, 134*(2), 317-340.

Kuwornu, J. K. M., Amegashie, D. P. K., & Wussah, C. E. (2012). Productivity and resource use efficiency in tomato and watermelon farms: Evidence from Ghana. *Developing Country studies, 2*(2), 23-37.

KwaZulu-Natal Department of Agriculture and Environmental Affairs (2003). Vegetable production in KwaZulu-Natal: *Tomato*. Retrieved from http://www.kzndard.gov.za/Portals/0/Horticulture/Veg%20prod/tomato.pdf

Lubungu, M., Burke, W. J., & Sitko, N. J. (2014). *Analysis of the sunflower value chain in Zambia Eastern Province.* (Working paper No. 85). Indaba Agricultural Policy Research Institute (IAPRI) Lusaka, Zambia.

Mallawaarachchi, T., Walcott, J., Hughes, N., Gooday, P., Georgeson, L & Foster, A. (2009, December). *Promoting productivity in the agriculture and food sector value chain: issues for R&D investment*. ABARE and BRS report to the Rural R&D Council, Canberra. Retrieved from http://www.daff.gov.au/SiteCollectionDocuments/ag-food/innovation2/rd-abare-report.pdf

Mijindadi, N. B. (1980). *Production Efficiency on Farms in Northern Nigeria*. (Unpublished Ph.D. Thesis). University of Cornell, Cornell.

Ministry of Food and Agriculture (MOFA) (2008). *Production guide for tomato.* MOFA Information Resource Centre.

Ministry of Food and Agriculture (MOFA) (2011). *Agriculture in Ghana: Facts and Figures (2010)*. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Ghana.

Ministry of Food and Agriculture (MOFA) (2013). *Agriculture in Ghana: Facts and Figures*. Retrieved from http://mofa.gov.gh/site/?page_id=6032

Minot, N., Epprecht, M., Anh, T. & Trung, Le Q. (2006). *Income diversification and poverty in the Northern uplands of Vietnam.* (IFPRI Research Report No. 145).

Morris, M., Kelly, V. A., Kopicki, R.J. & Byerlee, D. (2007). *Fertilizer use in African agriculture. Lessons learned and good practice guidelines*. (World Bank Directions in Development Report). Washington, DC: World Bank.

NaaDanJain Irrigation Limited (2012). *Tomato cultivation in open fields and greenhouses*. http://www.naandanjain.com/uploads/catalogerfiles/tomato-2/Tomato_eng_booklet_190812final%20.pdf

Namara, R. E., Horowitz, L., Nyamadi, B., & Barry, B. (2011). *Irrigation development in Ghana: Past experiences, emerging opportunities, and future directions.* (Ghana Strategy Support Program (GSSP) Working Paper No. 0027). Accra: IFPRI.

Ng'eno, V., Lagat, B. K., Korir, M. K., Ngeno, E. K., & Kipsat, M. J. (2010, September). *Resource Use Efficiency in Poultry Production in Bureti District, Kenya.* Poster presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa.

Norman, D. W., Worman, F. D. Siebert, J. D., & Modiakgotla, E. (1995). *The farming systems approach to development and appropriate technology generation*. (FAO Farm Systems Management Series No. 10). Rome: FAO.

Nuruddin, M. M. (2001). *Effects of water stress on tomato at different growth stages*. (Master's thesis, McGili University, Montreal).

Nwaru, J. C. (2004). *Rural credit markets and resource use in arable crop production in Imo State of Nigeria* (Unpublished Doctorate Dissertation). Michael Okpara University of Agriculture, Umudike, Nigeria.

OECD (2001). Measuring Productivity. *Measurement of aggregate and industry-level productivity growth.* OECD Manual.

Obasi, P. C., Henri-Ukoha, A., Ukewuihe, I. S., & Chidiebere-Mark, N. M. (2013). Factors affecting agricultural productivity among arable crop farmers in Imo State, Nigeria. *American Journal of Experimental Agriculture, 3*(2), 443-454.

Oehmke, J. F., Anandajayasekeram, P., & Masters, W. A. (1997). *Agricultural technology development and transfer in Africa impacts achieved and lessons learned*. (USAID, Office of Sustainable Development, Bureau for Africa, SD Publication Series, Technical Paper No. 77). Washington, D C.

Ojo, C. O., Bila, Y. & Iheanacho, A. C. (2012). Agricultural resource access and the influence of socioeconomic characteristics among rural women in Borno State, Nigeria. *Agris on-line Papers in Economics and Informatics, 4*(2), 27-33. Retrieved from http://online.agris.cz/files/2012/agris_online_2012_2_ojo_bila_iheanacho.pdf

Okrah, M. (2010). *Economic Dimension of the inland fisheries of the Upper East region of Ghana* (Unpublished master's thesis). Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Oluwadare, D. A., Imoudu, P. B. & Ogundari, K. (2009). Structure and performance of palm oil marketing in Ondo State, Nigeria. *Journal of Agriculture and Social Science, 5*(1-2), 23–26.

Omonoma, B.T., Egbetokun, O.A., & Akanbi, A.T. (2010). Farmers' resource – use and technical efficiency in cowpea production in Nigeria. *Economic Analysis and Policy*, *40*(1), 87-95.

Orzolek, M. D., Bogash, M. S., Harsh, M. R., Lynn, F., Kime, L. F., Jayson, K., & Harper, J. K. (2006). Tomato production. *Agricultural Alternatives Pub.* Retrieved from http://extension.psu.edu/business/ag-alternatives/horticulture/vegetables/tomato-production/extension_publication_file

Osteen, C., Gottlieb, J., & Vasavada, U. (eds.) (2012). *Agricultural resources and environmental indicators.* EIB-98, U.S. Department of Agriculture, Economic Research Service. Retrieved from www.ers.usda.gov/Publications/eib- economic-information-bulletin/eib98.aspx

Oum, T. H., & Zhang, Y. (1995). Competition and allocative efficiency: The case of the U.S. telephone industry. *The Review of Economics and Statistics, 77*(1), 82-96.

Pederson, P. (2008). *Soybean production*. Soybean Extension and research program. Iowa State University Extension. Retrieved from http://extension.agron.iastate.edu/soybean/production_plantpopulation.html

Purseglove, K. O (1979). *Tropical crops dicotyledons*. London: Longmans, pp: 199 – 237.

Quiñones, E. J., & Diao, X. (2011). Assessing crop production and input use patterns in Ghana –What can we learn from the Ghana Living Standards Survey (GLSS5)? *IFPRI's Ghana Strategy Support Program (GSSP) Working Paper* No. 0024

Rad, S., Ates, H. C., Delioglan, S., Polatoz, S., & Ozcomlekci, G. (2010). *Participation of rural women in sustainable development: Demographical and socio-economic determinants, sustainable development.* DOI: IO.IOO2/sd.451.

Randela, R. (2005). *Integration of emerging cotton farmers into the commercial agricultural economy* (Unpublished doctoral thesis). University of the Free State, Bloemfontein.

Redden, J. P., Mann, T., Vickers, Z., Mykerezi, E., Reicks, M., & Elsbernd, S. (2015). Serving first in isolation increases vegetable intake among elementary school children. *PLoS ONE, 10*(4), 1-14. doi:10.1371/journal.pone.0121283

Reddy, M, V. (1998). *Production and economic analysis of Fiji's sugar industry* (Unpublished doctoral dissertation). University of Hawaii.

Rejesus, R. M., Heisey, P. W., & Smale, M. (1999). *Source of productivity growth in wheat: A review of recent performance and medium-to long term prospects.* (CIMMYT Economic paper 19-05). Mexico D.F.

Robinson, J. Z. E., & Kolavalli, S. L. (2010a). *The case of tomato in Ghana: Productivity.* (Ghana Strategy Support Program (GSSP) Working Paper No. 19). Accra: IFPRI.

Robinson, J. Z. E., & Kolavalli, S. L. (2010b). *The case of tomato in Ghana: Marketing.* (Ghana Strategy Support Program (GSSP) Working Paper No. 20). Accra: IFPRI.

Sacco, A. (2008). Genetic mechanisms underlying tomato quality traits. *Università Degli Studi Di Napoli Federico,* 2, 1 – 16.

Saha, S. K., Pfeufer, E., Bessin, R., Wright, S., & Strang, J. (2015). Vegetable production guide for commercial growers, 2016-17.

Salassi, M. E., & Deliberto, M. (2011). *Rice production in Louisiana, soybeans, wheat and sorghum production in Southwest Louisiana*. (A.E.A (Agricultural Economics & Agribusiness) Information Series No. 266). Department of Agricultural Economics & Agribusiness. Louisiana State University Agricultural Centre.

Samboko, P. C. (2011). *An assessment of factors influencing the profitability of bean production in Zambia* (Bsc. dissertation, University of Zambia). Retrieved from http://valuechains.k-state.edu/Paul%20Chimuka.pdf

Sanchez, I. M. G. (2009). Technical and scale efficiency in Spanish urban transport: Estimating with data envelopment analysis. *Advances in Operations Research, 2009*. Retrieved from http://dx.doi.org/10.1155/2009/721279

Selamat, Z., & Nasir, A, M. (2013). Efficiency measurement of Malaysian agriculture firms. *International Journal of Trade, Economics and Finance, 4*(2), 79-85.

Shabu, T. (2013). Determination of resource use efficiency of rice farmers in Kaambe district of Guma local government area of Benue State, Nigeria. *World Journal of Agricultural Research, 1*(6), 143-148. Retrieved from http://pubs.sciepub.com/wjar/1/6/9

Shankara, N., Maijade, G., Matin, H., & Van Dam, B. (2005). *Cultivation of tomato, production, processing and marketing*. Agromisa Foundation, Wageningen.

Speelman, S., D'Haese, M., Buysse, J., & D'Haese, L. (2008). A measure for the efficiency of water use and its determinants, a case study of small-scale irrigation schemes in North-West Province, South Africa. *Agricultural Systems*, 98(1), 31 -39.

Srinivasan, R. (Ed.) (2010). Safer tomato production methods: A field guide for soil fertility and pest management. AVRDC – The World Vegetable Centre, Shanhua, Taiwan. *AVDRC Publication* No. 10 – 740. Pp 2 - 97.

Steduto, P., Hsiao, T. C., Fereres, E., & Raes, D. (2012). *Crop yield response to water*. (FAO Irrigation and Drainage Paper No. 66). Rome: FAO.

Stephen, J., Mshelia, S. I., & Kwaga, B. T. (2004). Resource-use efficiency in cowpea production in the North-Eastern zone of Adamawa State, Nigeria. Department of Forestry and Wildlife Management, Federal University of Technology. Yola, Nigeria.

Sugri, I., Sargent, S. A., Kusi, F., Berry, A. D., Kanton, R. A. L., & Pelletier, W. (2013). Improving marketable quality of tomato: A simulation of shipping conditions in Ghana. *American Journal of Experimental Agriculture, 3*(2), 392-402.

Swanson, B. E. & Claar, J. B., (1984). Defining extension Agricultural extension: A reference manual. Alternative models and recent trends in organizing agricultural Extension. Food and Agriculture Organization of the United Nations. Rome.

Swanson, B. E., Bentz, R. P., & Sofranko, A. J. (eds) (1998). Improving agricultural extension: A Reference Manual. Food ana Agriculture Organisation of the United Nations, Rome Italy.

Tambo, J. A., & Gbemu, T. (2010, September). *Resource-use efficiency in tomato production in the Dangme west district, Ghana.* Tropentag 2010 ETH Zurich, Conference on International Research on Food Security, Natural Resource Management and Rural Development.

Taye, H. (2013). Evaluating the impact of agricultural extension programmes in sub-Saharan Africa: Challenges and prospects, *African Evaluation Journal, 1*(1). Retrieved from http://dx.doi.org/10.4102/aej.v1i1.19

Tetteh, N. J. (2013). *Smallholder access to agricultural productive resources in the Dangme East and west districts of Ghana, (*Unpublished master's dissertation). University of Ghana, Legon.

Thepa, G. (2009, February). *Smallholder farming in transforming economies of Asia and the Pacific: Challenges and opportunities.* Discussion paper prepared for the side event organized during the Thirty-third session of IFAD's Governing Council.

Tindall, H. D. (1988). *Vegetables in the Tropics*. Mcmillan publisher, Hong Kong pp 351-359.

Todaro, M. P., & Smith, S. C. (2012). *Economic development* (11th ed.). Boston: Addison-Wesley.

Tran, D. V. (2005). Overview on tomato production and tomato varieties in Vietnam. Center for Agricultural Research and Ecological Studies (CARES), Hanoi Agricultural University, Hanoi.

Upton, M. (1987). *African farm management.* UK: Cambridge University Press.

USDA (1997). *Agricultural resources and environmental indicators, 1996-97. U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environment Division.* (Agricultural Handbook No. 712). Washington, DC.

Van den Ban, A.W. & Hawkins, H.S. (1996). *Agricultural extension* (2nd ed). Oxford: Blackwell Science.

Van Der Merwe, E. (2012). *Economic literacy as a factor affecting allocative efficiency (*Master's dissertation, University of the Free State, Bloemfontein). Retrieved from http://etd.uovs.ac.za/ETD-db/theses/available/etd-08162012-113236/unrestricted/VanDerMerweE.pdf

Vu, L. H. (2008). *Essay on the economics of food production and consumption in Vietnam.* (Doctoral thesis, University of Minnosota).

Waddington, H., Birte, S., White, H. & Anderson, J. (2010). *The impact of agricultural extension services.* (3ie Synthetic Reviews – SR009 Protocol), International Initiative for Impact Evaluation, New Delhi. Retrieved from http://www.3ieimpact.org/media/filer_public/2012/05/07/009%20Protocol.pdf

Witte, R. (2004). Enterprise budgets and variable costs. Stichting Agromisa, Wageningen. Retrieved from http://www.ruralfinance.org/fileadmin/templates/rflc/documents/1157036313687_AB2_varcost.pdf

World Bank (2000). World Bank Africa database 2000 CD-ROM (World Bank, Washington D.C.).

World Bank (2009). *Annual report, 2009- year in review*. Washington, DC: World Bank.

World Bank (2015a). World Bank database 2015. Washington DC: World Bank. Retrieved from http://www.worldbank.org/en/topic/agriculture/overview

World Bank (2015b). World Bank database 2015. Washington DC: World Bank. Retrieved from http://data.worldbank.org/indicator/SP.POP.1564.TO.ZS

World Bank (2016). *Fertiliser consumption (kilogram per hectare of arable land)*. World Bank data base. Washington DC: World Bank. Retrieved from http://data.worldbank.org/indicator/AG.CON.FERT.ZS/countries

Xaba, B. G., & Masuku, M. B. (2013). Factors affecting the productivity and profitability of vegetables production in Swaziland. *Journal of Agricultural Studies, 1*(2), 37-52. doi:10.5296/jas.v1i2.3748

Yawson, D. O., Armah, F. A., Afrifa, E. K. A., & Dadzie, K. N. (2010). Ghana's fertiliser subsidy policy: Early field lessons from farmers in the Central Region. *Journal of Sustainable Development in Africa, 12* (3), 191-203.

Yeboah, A. K (2011). *A survey on postharvest handling, preservation and processing methods of tomato (Solanum lycopersicum) in the Dormaa and Tano south districts of the Brong Ahafo region of Ghana* (Unpublished master's thesis). Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Yilma, T. (2006). Market survey in the Upper East region of Ghana. Integrating Governance and Modeling Project (CPFW). Colombo, Sri Lanka: CPWF. 16 p. Retrieved from http://hdl.handle.net/10568/17077

APPENDIX

QUESTIONNAIRE FOR ALLOCATIVE EFFICIENCY OF IRRIGATED TOMATO PRODUCTION IN THE UPPER EAST REGION, GHANA

PRODUCERS' COPY

The confidentiality of the respondents profile will not be compromise in any way and will thus not pose any consequences on the respondent. Please give correct answers to the following questions.

INSTRUCTIONS TO ENUMERATOR

- Make a brief introduction of yourself before any questions and clearly state the objectives of the study to the respondent. Relate to respondents in local language.
- Ask each question clearly and patiently until respondent gets the understanding.
- Avoid the use of technical terms and also use local units.
- Fill interview schedule according to the responses of the respondent and answers should be fill in the appropriate spaces provided.

(A) Demographic Characteristics

1. Name of community...
2. Name of farmer (optional)...
3. Sex (1) M (0) F
4. Age [ ] years
5. Marital status: (0) single (1) Devoiced (2) Married (3) Widowed

6. What is your main occupation? …………………………………….............................

7. What is your religion?: (0) Muslim (1) Christian (2) Traditionalist (3) None

8. What is your level of education?: (0) No formal education (1) Primary (2) Junior High (3) Secondary (4) College/Polytechnic (5) University

9. How many children do you have? ……………………………….....................................

10. Number of children < 13years ☐ >13years ☐

11. How many are going to school? .... Also indicate the level of education attained by children (0) Nursery……. (1) Primary ……. . (2) Secondary…….. (3) Tertiary …….

12. Are you a member of any farmer group? (0) Yes (1) No

(B) Tomato Production

13. When did you start producing tomato? ....

14. What tomato variety / varieties do you cultivate? ....

15. Which variety did you grow last season (2013/2014 cropping season) (0) local (1) improved

16. How long have you been growing this variety? ....

17. Why do you grow this variety?

....

....

18. Which variety(s) do consumers prefer?

....

19. Where do you always obtain purchased input (e.g. fertiliser, seeds, pesticides, fungicides, weedicides and tractor mechanisation services)? (0) Private input dealers (1) Government

(MOFA) (2) NGOs (3) Other

(Specify)…………………………………………………………..

20. When the inputs listed in "Question 19" are not supplied by the private input dealers, what then is (are) always the terms of supply? (0) Subsidised (1) Free (2) Contract farming (1) other
(specify)...

21. Are agro inputs readily accessible (0) Yes (1) No
22. Are Agro input readily available in the markets when needed (0) Yes (1) No
23. What size of land did you cultivate tomatoes last season? ....
24. How would you describe your output in tomato production over the years? (1) Stagnant (2) Increasing (3) Decreasing (4) Fluctuating
25. What do you think is the reason(s) for the answer given for question (21)?
....
....
....
....
26. How do you acquire land for your production? (0) Rent (1) Inheritance (2) purchases (3) others (specify)...
27. How do you finance your production? : (0) Loan from a bank (1) Own capital
(2) Borrowing from relatives or friends
(3) Others (specify)...
28. Did you take a loan for the 2013/2014 production season? (0) Yes (1) No
29. If yes, how much? ....

30. At what interest rate? ....

31. Did you receive any visits from extension officer? (0) No (1) yes

32. What was/were the visit(s)

about?...

....

....

(C) Production Cost

C i) Fixed Cost of inputs

INPUTS/EQUIPMENT	28. QUANTITY	29. UNIT COST (GH₵)	30. TOTAL COST(GH₵)	31. USEFUL LIFE IN YEARS
LAND				
CUTLASS(ES)				
HOES				
WELLINGTON BOOTS				
SPRAYING MACHINE				
MOTORISED PUMPING MACHINE				
OTHERS				

C ii) Variable Cost of inputs

INPUT	32. QUANTITY (kg, acre, millilitres etc.)	33. UNIT COST(GH₵)	34. TOTAL COST(GH₵)
PLOWING (raising of ridges			
SEEDLING/SEEDS			
WEEDICIDES			
STALKING			
FERTILISER			
FUNGICIDES			
INSECTICIDES			
HARVESTING			
FUEL COST			
MAINTENANCE COST			

C iii) Variable Cost Inputs (Labour in Man-days)

INPUT(LABOUR IN MAN-DAYS)	35. FAMILY (QUANTITY)	36. FAMILY (COST)	37. HIRED (QUANTITY)	38. HIRED (COST)
LAND PREPARATION				
NURSING OF SEEDLING				
PLOUGHING				
SOWING/ TRANSPLANTING				
WEEDING				
FERTILIZER APPLICATION				
WEEDICIDE APPLICATION				
INSECTICIDE APPLICATION				
FUNGICIDE APPLICATION				
HARVESTING				
TRANSPORTATION (to store, market, etc)				
WATERING				
OTHERS				

(C iv) Output

FARMER	39. QUANTITY HARVESTED (KG)	40. TOTAL QUANTITY SOLD (KG)	41. TOTAL QUANTITY GIVEN AS GIFTS (KG)	42. TOTAL QUANTITY CONSUMED BY FAMILY (KG)

(C v) Revenue;

PERIOD	**43. QUANTITY SOLD**	**44. PRICE**	**45. REVENUE**
OCT-DEC			
JAN- MARCH			
APRIL-JUNE			
JULY-SEPT			

46. What other benefits do you derive from tomato production?

....

....

....

47. Where do you sell your produce after harvest? (0) Farm gate (1) Local market (2) District market (3) Regional market (4) others (specify)...

48. To whom do you sell? (0) Consumer (1) Wholesaler (2) Retailer (3) Processor (4) Brokers (5) Other (specify)…… ……………………………………………………

49 What were the terms of trade? (0) Cash (1) Credit (2) Advance payment

50. Who determined the market price in 2013/2014? (0) yourself (1) Consumer (2) Traders (3) Negotiation (4) Other (specify)………………………………………………………

51. What has been the price trend in the past 5years? (0) Stable (1) Increasing (2) Decreasing (3) Fluctuating

What do you do when you do not get expected price for your tomato fruit? (0) Take back home (1) sold at lower price (2) Other ……………………………………………………..

52. Do you always get ready market? (0)Yes (1) No

53. If no to “question 52” why? (0) lack of information (1) Low price (2) Inaccessibility of market (3) other (specify)…………………………………………………………

End of interview

Thank you for your cooperation.

Name of enumerator …………………………………………..

Date of interview…………………….