UNIVERSITY FOR DEVELOPMENT STUDIES

RESOURCE USE EFFICIENCY OF ONION FARMERS IN THE UPPER EAST REGION OF GHANA

AKANLIK VITUS ANYATENGBEY

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BY

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRICBUSINESS AND APPLIED ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

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DECLARATION

I, Anyatengbey Akanlik Vitus, do hereby declare that this thesis work submitted for a degree of Master of Philosophy in Agricultural Economics, is my own independent work under the guidance of my supervisors at the University for Development Studies and that this work has never been presented either in whole or partially by me for any degree in this University or elsewhere. I do further declare that all literature works in this thesis have been duly acknowledged.

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Supervisors

We declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines for thesis supervision laid down by University for Development Studies.

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ABSTRACT

The productivity and benefits of agricultural production depends on the efficient use of agricultural inputs. This research work therefore examined the efficiency with which farmers use their productive resources in producing onion in the Upper East Region of Ghana. The study used a sample of 272 onion farmers selected from three (3) onion-producing districts in the Upper East Region. Primary data were collected through face-to-face interviews using semi-structured questionnaires to solicit information from onion farmers. Using the Maximum Likelihood Estimation of the stochastic frontier function, it was found that farm size, seed, labour, fertilizer and mechanisation had positive influences on technical and allocative efficiencies of onion producers at varying significant levels. Age, access to credit and water pump were found to influence technical efficiency positively but farm size was positively related to technical inefficiency at 5%. Water pump usage, access to extension services and farm size were positively related to allocative efficiency at 1% with age having a negative influence on allocative efficiency at 5%. The study found mean score of 0.904, 0.896 and 0.810 for technical, allocative and economic efficiencies, respectively. The resource use efficiency ratios show that onion farmers were under-utilising land, seed and fertilizer but are over-utilising water pumps. There is the need to extend subsidy to all agrochemicals and agricultural machines. The study recommend that government should priorities the funding of extension delivery system, pursuing policies to increase irrigation schemes in the region and make efforts in providing affordable credit facilities to farmers in order to sustain or improve the efficiencies of onion farmers.

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This thesis work is dedicated to Miss Hannah Anyavuusumbey (my wife), Awenniami and Apakwen (my daughter and son) and the eternal memory of my parents Mr. Anyatengbey Abaadema and Mrs. Margaret Alediin Anyatengbey, I love you all.

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LIST OF ACRONYMS

AE	Allocative Efficiency
DEA	Data Envelop Analysis
EE	Economic Efficiency
ER	Resource-Use-Efficiency Ratio
FAO	Food and Agricultural Organisation
FBO	Farmer Based Organisation
GDP	Gross Domestic Product
GSS	Ghana Statistical Service
ISSER	Institute of Statistical Social and Economic Research
LR	Likelihood Ratio
MFC	Marginal Factor Cost
MPP	Marginal Physical Product
MVP	Marginal Value Product
MLE	Maximum Likelihood Estimation
MOFA	Ministry of Food and Agriculture
Mt	Metric tonnes
NGOs	Non-governmental Organisations
SFA	Stochastic Frontier Analysis
SFP	Stochastic Frontier Production
SSA	Sub-Saharan Africa
TE	Technical Efficiency

CHAPTER ONE

INTRODUCTION

1.1 Background

Agricultural development in the area of crop, vegetables, fruits and other allied activities occupy a significant place in the economic growth of Ghana. This is to ensure an increase in agricultural production to satisfy the food needs and other agricultural commodities because of the increasing population of the country. Agricultural output of any specific crop can be increased through increasing the land size used for the cultivation of the crop or intensifying the productivity per unit of land. However, with the persistent population growth and decreasing supply of arable land per capita in developing countries, there is a growing need for the increase in total agricultural production to emanate from productivity growth instead of expansion of land (Heisey, 2015).

The adoption of improved agricultural production technologies is critical for enhanced productivity. According to Akudugu *et al.* (2012), the adoption of improved technologies by farm households depend on the gains of adopting such technologies, farm size, extension services and access to credit. Technologies that are found to increase productivity of agricultural production include; the use of improved crop varieties, application of fertilizer, improved water management practices, agronomical and farm management practices (Feed the Future, 2012).

Ghana's food crop production is still dominated by small-holder farmers with less than two (2) hectares of farm size and provides two-thirds of the total food production in the country (MOFA, 2016). The predominant reliance on traditional tools for farming by farmers for substantial part of agricultural production activities has been partly responsible for low level of production. It is against this backdrop that the government and many donor agencies have encouraged and supported these small-holder farmers to adopt new technologies to improve their production in response to increasing population over the years. Despite years of adopting the improved technologies in agricultural production, the sector still experiences low productivity. The consequences of the low productivity have always led to the failure to attain self-reliance in food production creating food deficits, which have been attributed to inefficiencies in production and resource use (Adeoye & Balogun, 2016).

Agricultural production is essential for three core reasons: the production and consumption of food crops, raw materials for industrial improvements and revenues for government. These core reasons have drawn the attention of policy makers who have often viewed the sectors as major tools for generating revenue, reducing the dependence on foreign imports, stable and sustained job creation for reducing poverty and food security as a means of curtailing malnutrition and environmental sustainability. Vegetables production as one of the segments of the crop sub-sector of agriculture is perceived as a potential sector that can provide opportunities for increasing agricultural production, job creation and foreign exchange through exportation. (MOFA, 2015).

Onion (*Allium cepa* L.) has been noted as one of the known ancient vegetables and is said to originate near East and Central Asia (Sinnadurai, 1970). It is a major vegetable crop in West Africa, which was introduced by the early Europeans. Onion was introduced into Ghana from Burkina Faso and Northern Nigeria around 1930 and was first grown at Bugri, near Bawku from where it spread to other parts of the country (Obeng-Ofori *et al*., 2007).

Onion is cultivated for its strong flavour and is used in the preparation of many dishes around the world. The vegetable has a reasonable high value in food. The onion bulb contains 89% water and a 100g edible portion of the vegetable has 31 calories energy; protein, 1.1g; fat, 0.1g; total sugar, 4.2g; other carbohydrates 9.3g; thiamine B1, 0.04mg; riboflavin (B2), 0.02mg, niacin (B3), 0.1mg; ; Pantothenic acid (B5), 0.12g; vitamin B6, 0.12mg; vitamin C, 31.2mg; iron, 0.21mg; Magnesium, 10mg; calcium, 23mg; manganese, 1.29mg; potassium, 46mg; phosphorus, 29mg; zinc, 0.17mg (Upadhyay, 2016). According to Karthick *et al.* (2015), the existence of alliaceous fragrance in onion explains its usage in food as salad, spices, condiment and in medicine. Ashwini and Sathishkumar (2014) stated that several diseases could be treated by using onion, especially the cardiovascular health conditions. Although onion is considered as an important vegetable crop and a constituent of a balanced diet, its production serves as a source of income for many people in Ghana. The cultivation of onion serves as a source of income for onion farmers, agrochemical dealers, middlemen, carters, transporters and traders and thus its contribution to the economy of Ghana cannot be overemphasised. DAI (2014) reported that MOFA in 2012 had attributed the low migration of the youth from the onion producing areas in the country to the dry season cultivation of the crop which coincides with the period of migration for most people from the north to the south of Ghana to search for jobs.

The global production of onion has experienced a steady increase in terms of cultivated area and output volume. Onion is cultivated in nearly 180 countries in the world with China, India, USA, Egypt, Islamic Republic of Iran, Russia federation and Turkey been the major onion producers. Over three (3) million hectares of land is under onion cultivation worldwide. Netherlands and USA have the highest yield of 67.8 Mt per hectare and 59.6 Mt per hectare respectively (FAO, 2016). Ghana is the 4th leading producer of onion in West Africa behind Nigeria, Niger and Senegal with a total output of 143, 982 Mt representing 0.02% of the world onion output (FAO, 2016).

In Ghana, onions are presently grown mostly in the north especially in Upper East Region as well as Eastern Region in the south. It is cultivated in the dry season although it can be also cultivated in the rainy season (Akrofi *et al.*, 2015). The soil requirement for the cultivation of onion is a well-drained soil, which contains sufficient amount of humus such as the alluvial types of soil, fertile loamy soil and humus rich sandy soil. In the dry season, the soil for cultivation of onion should be able to hold a considerable amount of moisture since it is a prerequisite for high biological activities in the soil (DAI, 2014). An average rainfall between 500mm-1000mm with temperature range of 25°C to 30°C allow for the cultivation of onion (Akrofi *et al.*, 2015).

Onion is second most important vegetable in Ghana in terms of production and consumption and thus performs an essential role in the economic development of Ghana (Gonzalez *et al.*, 2016). Despite the existence of large size of land and huge human resources in Ghana, the country is not self-sufficient in onion production. Ghana's onion consumption needs exceed production and so millions of dollars are spent annually to import dry onion bulbs from neighbouring countries (Ghanaweb, 2017). The average yield of onion in Ghana is about 15 metric tonnes per hectare and this is low compared to that of the average yield of 35 metric tonnes in Niger (FAO, 2016).

The inability of small-scale onion farmers to adopt improved agricultural technologies and their inefficiencies in resource (inputs) allocation and utilization could be the causes for the low average yield of onion production in Ghana despite the support given to the industry by government, donor agencies and other stakeholders (DAI, 2014).

Therefore, farmers need to make efficient use of current inputs and resources in a balanced manner to increase the productivity and income of onion farmers. Farmers' knowledge in the various kinds of expenses associated with production and the benefits derived from such production is vital in order to reduce the risk element of farming and for easy adoption of improved technology in onion production. Farmers will allocate a manageable size of land for the production of the vegetable to attain the desired benefits if they are provided with such important information.

1.2 Problem statement

The contribution of the agricultural sector towards the development and advancement of the Ghanaian economy despite the discovery and production of oil in the country cannot be overlooked. The sector was responsible for employing 40% of the labour force (MOFA, 2016), 19.1% of the country's Gross Domestic Product (GDP) (GSS, 2017) and 29% of foreign exchange (ISSER, 2017). The sector despite recording reductions in its growth rate over the few years still remains relevant towards the socio-economic development of the country through the provision of food crops for sustained and continual food security.

Recent concerns on food security in Ghana have generally been centred on measures that are meant to increase agricultural output through efficiency in the use of inputs in production. This has arisen due to the subsistence nature of the country's agriculture, changes in climatic conditions due to global warming and high rate of population growth with increase in agricultural production not keeping pace with the population growth (Darfour & Rosentrater, 2016). Population increases also tends to put a further push on the demand for food. The rise in population and changing climatic conditions require that resources are judiciously used to increase agricultural productivity and outputs to correspond with the rise in demand for food both locally and globally. These resources could be natural or manmade. The man-made resources such as labour, capital and entrepreneurship are provided and influenced by man (Debertin 2012).

Generally, onions are cultivated in commercial quantity in the Upper East, Northern and Eastern regions of Ghana. However, the yield in the country is low compared with other countries in Africa or the world. The low yield of the vegetable has been attributed to low adoption of improved varieties, poor farm management and agronomic practices, disease and pest problems. As a result, the demand for onion in the country exceeded its domestic supply leading to the importation of the vegetable from neighbouring countries in West Africa to supplement the quantity produced. For instance, *citifmonline* business news on Monday, 23rd October 2017 reported that Ghana spent over $120 million on importation of onion from Niger and other countries which could be domestically produced. Asselt *et al.* (2018) estimated that, Ghana spent over $52 million on importing 862,190mt of onion annually in to the country from Niger and Burkina Faso. Therefore, there is the need to increase domestic output of onion to meet the 11% annual growth rate in its demand in the country.

The small-scale onion farmers at the farm level employ many resources with attendant low output. The low productivity and output have been partly linked to inefficiency of onion farmers and resource allocation (DAI, 2014). It is therefore crucial to know how the efficiency of small-scale onion farmers will be raised in order to help them reduce waste in production.

This work will therefore seek to estimate the efficiency of onion farmers in using their resources in Upper East Region of Ghana. Notwithstanding the important role of onion cultivation in the region, there seem to be scanty literature on onion efficiency and productivity by researchers in the region with most empirical research in region directed at rice, maize and tomatoes production. The study is also aimed at ascertaining the extent to which onion production could be increased using present resource base and available technology, which can help in policy formulation on the bridging the deficiency in domestic output due to inefficiencies.

1.3 Research questions

In a view to fill up the gap in research on the resource use efficiency of onion farmers in Ghana, the central question was, what is the level of resource use efficiency of dry season onion farmers in the Upper East Region of Ghana? To accomplish this, the following specific questions were raised:

1. What factors determine the output of onion farmers in the Upper East Region?
2. What are the technical, allocative and economic efficiencies of onion farmers in the region?
3. What are the efficiency differences between pump users and non-pump users in onion cultivation in the region?
4. What is the level of resource use efficiency of onion farmers in the region?
5. How can resource use efficiency in the region be improved and /or sustained?

1.4 Objectives of the study

The central goal of the study was to assess the resource use efficiency of dry season onion farmers in the Upper East Region of Ghana. Specifically, the study sought to:

1. Examine the determinants of output of onion farmers in the region
2. Determine the technical, allocative and economic efficiencies of onion farmers
3. Estimate the efficiency differences between pump users and non-pump users in onion cultivation in the region
4. Determine the resource use efficiency of onion farmers

5. Assess how resource use efficiency in the study area can be improved and/ or sustained.

1.5 Significance of the study

The need for agricultural growth through productivity improvement as stated by Aneani *et al.*, (2011) is paramount to the revival of the industrial sector of the country through agro-processing (GOG, 2019) in order to provide good livelihood for the rural people through the elimination inefficiencies of farmers. Abdulai (2006) asserted that low output realised by small-scale holders (farmers) is a sign that resources required in the cultivation of crops are not at optimal levels due to inefficiencies by farmers. Danso-Abbeam *et al.*, (2015) in their contribution stated that rural farmers must be trained on farm management through extension work in order for farmers to improve the efficiency in the use of scarce resources in cultivation to achieve optimum production level.

Successive governments and other stakeholders have come up with various programmes and policies to achieve food self-sufficiency to meet the expanding population but the outcomes are not encouraging as productivity is still low. Studies on horticultural plants have often concentrated on the challenges of marketing the crops. Though, marketing is important, a research into the productivity and efficiency of vegetables cultivation will enhance the output and promote of the work of academia.

Over the years, policy makers in the country have developed interest in the production of vegetables particularly onion (MOFA, 2015) leading to an increase in output from

29,510 mt in 1995 to 143,982 mt in 2016 (FAO, 2017). Notwithstanding the increase in output level, there are still challenges confronting the productivity and efficiency of onion cultivation. The study would therefore look at the production and efficiency of the onion sector.

The need to examine the production and efficiency of onion cultivation in the Upper East region becomes necessary owing to the demand - supply gap and the need to conserve foreign currency used in the importation of onion (Gonzalez *et al.*, 2016). The study becomes necessary too, because, in spite of the potentials of the region in terms of the favourable weather conditions for onion production and human resource, the yields per hectare of the farmers are low. Also, the efficiency with which small-scale farmers uses available resources and technology becomes a matter of concern for investigation. Fundamentally, advocating for the adoption of new technologies to increase output would be cost effective if farmers are found to be efficient in the use of the current technologies (Shappiro, 1983; Belbase & Grabowski, 1985).

A considerable increase in the production of onion would thus provide the needed raw materials for onion processing as envisage by the "one district, one factory" policy (Ghanaweb, 2017) leading to the creating of job opportunities for the labour force.

The significance of the study would be to broaden the discussion on measures aimed at improving the efficiency of Ghana's onion industry. It is anticipated that the results of this research work will give specific guidance to the onion farmers and policy makers in the study region and Ghana as a whole. It will also help in identifying their production constraints and proffer recommendations with a view to increasing productivity vis-a-vis the income level of farmers as well as to improve their way of life. The study will thus assist in establishing the effectiveness of small-scale onion farmers' allocation of inputs in onion production. It is important that farmers are efficient in the use of productive resources to achieve maximum productive since increasing the productivity through efficient utilization of onion farmers will have great implications for total output, food security and development. More so, the outcomes of this study would help policy makers in formulating strategies to increase onion production in the region and the whole nation. The research work will help rural officials in the Ministry of Food and Agriculture as well as other departments and stakeholders in the country in their planning activities as regards efficiency of available resources for increased productivity.

The researcher was also motivated by the desire to contribute to the stock of knowledge on resources use efficiency. Thus, researchers will likewise gain immensely from the results of the study as a reference material.

1.6 Limitations of the study

This study focuses on resource use efficiency of onion farmers in the Upper East Region and thus, it is limited in scope and resources.

The researcher also faced difficulty in the data collection due to the dispersed location of farmers, unwillingness of farmers to sacrifice almost 2 hours of their farm work in answering the questionnaire, disruption of data collection by rains, and demands for gifts or money by some farmers. The questionnaire and interview guide were used as the instruments to solicit comprehensive information from respondents. Also, the information provided by the farmers used in this study was mainly from memory recall as many of them do not keep written records of operation. This took time than anticipated to collect the data in the study area. In spite of these limitations, the data errors were minimized while ensuring that all relevant information for the study was captured.

1.7 Organisation of the study

This research work is divided into 5 chapters including this chapter on introduction. Chapter 2 focused on review of empirical literature and presentation of the theoretical framework. The Stochastic Frontier Production function methodology was also briefly reviewed in this chapter. The analytical framework of the study and a description of the study area including the location, physical environment and demographic characteristics as well as the methods of data collection, sampling procedure and onion production in the study area were presented in Chapter 3. Chapter 4 was dedicated to presentation and discussion of results. The main characteristics of the sampled farmers are outlined and discussed. The results and discussion of resource use efficiency of onion farmers in the region are presented in this chapter. The summary, conclusions and recommendation based on the results and discussion are presented in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter covers a summary of relevant works related to efficiency studies. It presents a review of studies on agricultural production to discover evidences that will offer the background to understanding this research work. It begins with productivity in agriculture and how it is measured. This is then followed by efficiency, types of efficiency, different approaches of measuring efficiency, empirical application of Data Envelope Analysis (DEA) and Stochastic Frontier Analysis (SFA) in estimating technical efficiency, onion production, determinants of onion productivity and efficiency as well as the constraints in onion production.

2.2 Agricultural productivity and its measurement

Over the last five decades, a great deal of studies (Aigner et al., 1977; Battese & Coelli, 1993; Kantariya *et al.*, 2018) has been directed towards agricultural productivity growth in Africa due to its contribution to the growth and development of countries in the continent (Bruce *et al.*, 2007). Production in agriculture still remained the source of income for many rural people in Sub-Saharan Africa (SSA), which can lead to poverty reduction (Amisah *et al.*, 2002). Agricultural productivity helps to promote rapid agricultural output growth through the reduction in food and other agricultural products deficit gap in countries (Ehui & Punder, 2005: Bruce *et al.*, 2007).

Productivity is defined as the ratio of output to the inputs used in production (Fried *et al*., 2008). Agricultural productivity refers to the ratio of output of agricultural production to the inputs used in obtaining that output. Measurements of agricultural productivity have become a major area of concentration by researchers due to high population growth with its resultant high demand for food (Alene & Hassan, 2003). Increase in population will lead to the quest to bring more land under agricultural production to ensure food security. Accordingly, researchers have been trying to find new ways of increasing the yield and efficiency in agriculture. Increasing the per unit output have been recognized by researchers to be among the most ideal approaches of ensuring food security (Rangal, 2013). Therefore, there is the need to measure the current efficiency of production in agriculture in order to identify areas that need modification to improve food security (Lenis *et al*., 2010; Mapula *et al*., 2011; Rangalal, 2013).

Many researchers (Abramovitz, 1956 & Solow, 1957) based on their own viewpoints have endeavored to measure agricultural productivity in diverse ways. The result of their works is the categorisation of agricultural productivity measurements into partial and total factor productivity. The number of inputs used becomes the basis of the categorisation into these two measures. The partial productivity measure is viewed as the proportion of the physical output of yield to one unit of a factor of production used. This is also known as the Single Factor Productivity (SFP). The basic inputs used in measuring partial productivity are land, labour and capital. These partial productivities are key measures of wellbeing and therefore can be adjusted to improve the wellbeing of society. Labour productivity measured in terms of per capita income can be used to measure the wellbeing of rural farmers whiles land policies can be formulated to improve food security at the national level. Notwithstanding the significance of measuring SFP in solving specific issues, they are incomplete measures of productivity in agriculture since only single factors of production are measured at a time. Thus, when these partial productivity measures are considered in isolation, it can lead to a misrepresentative indication of overall productivity (Bamidele *et al.,* 2008).

Therefore, other scholars including Van Biesebroech, (2007) were motivated to conceive another suitable approach to measuring the overall productivity, which became known as the Total Factor Productivity (TFP). The TFP basically measures the change in total output of agricultural production in relation to changes in the combined effects of several factors of production (Christensen, 1975). Olayide and Heady, (1982) stated that, TFP is the proportion of the value of the total output of a farm to the value of all farm inputs used in production. TFP thus measures the total performance of agricultural inputs used to produce a given output (Diewert, 1976; Hulten *et al.,* 2001). The major problem associated with TFP is the challenge in combining farm inputs when data on price is not available.

Understanding the connection between productivity and efficiency in agricultural production is absolutely necessary in the process of helping farmers since many of them are saddled with issues regarding productivity and efficiency in the production process. Productivity basically has to do with the rate of production whereas efficiency considers the level of production vis-a-vis resource allocation and cost associated with production (Helmut, 2013). The relationship between productivity and efficiency implies that efficiency can be used to promote farm productivity (Coelli *et al*., 1998). Although the existence of inefficiency in the production process affects all farms, smaller farms may not be expanded due to costs associated with efficiency regardless of their nature.

2.3 The concept of efficiency of the firm

The foundational efforts of Farrell (1957) cannot be disregarded when it comes to efficiency measurement. Efficiency refers to the attainment of the highest conceivable output from using a set of inputs in the production process if all inputs and outputs are correctly measured (Farrell, 1957). In general, analysis of efficiency is focused on the likelihood of achieving a possible optimum output from a given set of inputs or at the lowest cost. Measurements of efficiency which indicate level of performance is valuable in formulating and examining policies for improving agriculture and essential in expanding growth in the agricultural sector in economies with scarcity of productive resources (Ali & Chanudhry, 1990). These countries have the potentials to gain significantly by influencing the scope to which productivity can be raised or using technology and the resources available to increase their efficiency level (Alvarez & Arias, 2004). It is therefore imperative to understand the different types of efficiency as presented in the following subsections.

2.3.1 Technical efficiency

Technical efficiency refers to the degree of achievement of the highest conceivable output from the usage of a given set of inputs used in production or the ability of a firm to get optimum output from a given set of inputs. Koopmans (1951) and Farrell (1957) pure and relative efficiencies measures of technical efficiency are two perspectives widely used in economic literature (Cooper et al., 2004; Greene, 2005). For a producer to be technically efficient according to Koopmans (1951), an increase in output would involve an increase in at least one of the inputs used in production or a decrease in at least one of the other outputs whilst a reduction in any input entails an increase in at least one of the other inputs or a decrease in at least one of the other outputs. Debreu (1952) and Farrell (1957) note that a firm can disregard the Koopmans' definition and still be efficient if it operates along the production frontier. A producer is said to be relatively technically efficient if the evidence indicates that other producers cannot improve some inputs and output without adjustment in other inputs or output (Cooper *et al.*, 2004).

According to Carson (1968), technical efficiency shows the ability of a firm to execute best practices in an industry to enable it achieves the best possible output with a given amount of inputs. A firm that is able to produce the highest possible output with a given set of inputs or produce a given level of output with a least quantity of inputs is said to be technically efficient. To Greene (2005), technical efficiency refers to the relationship between actual production output and conceivable production output. In other words, technical efficiency refers to the proportion of observed output to the potential output designated by the production frontier. Cooper *et al.*, (2004) additionally expressed that, technical efficiency refers to the level to which a firm employs a least set of inputs to produce a given level of output or produces an optimal output using a minimum set of inputs.

Tadesse and Krishnamoorthy (1997) found a substantial contrast in technical efficiency over the farm size groups with farmers working on small and medium farm sizes being more efficient than those with large farm size. They contended that small farm size owners are forced to allocate their insufficient resources more efficiently because access to credit from financial institutions depends on collateral security particularly land which they are disadvantage. Baree (2012) applied a Cobb-Douglas stochastic function to estimate the overall farm-specific technical efficiency or inefficiency of onion farms of Bangladesh and had mean specialized productivity of onion farms to be 83%. He found out that land, labour and capital had positive influence on technical efficiency of onion farmers. Age, experience and farm size were found to reduce the level of inefficiency of onion farmers.

2.3.2 Allocative efficiency

Allocative efficiency refers to the degree to which farmers take productive decisions by employing factors of production up to the level at which their marginal value product is equal to their marginal factor cost (MVP = MFC). According to Cooper *et al*. (2004), allocative efficiency also known as price efficiency reveals the capacity of a farmer to allocate productive resources in the best way given their respective costs. Allocative efficiency can be considered as the choice of the best mix of inputs vis-à-vis their relative factor costs (Farrell, 1957). A firm is said to be allocatively efficient if is able to equate its marginal value product to its marginal factor cost (Kalirajan & Shand, 1999). Nargis and Lee (2013) viewed allocative efficiency as using a given level of technology to change input into output to reflect the given price of input. With allocative efficiency, the society is not only interested in turning inputs to output but also the balancing of inputs into obtained that output level given their respective prices. In this method, the MVPs for each input used is computed and then compared with their respective purchase cost (MFC).

2.3.3 Economic efficiency

Economic efficiency is the outcome of the product of technical efficiency and allocative efficiency (Farrell, 1957; Kalarijan, 1990). The capacity of a farmer to obtain the optimum output from the best combination of productive resources given their respective prices is known as economic efficiency. Based on Farrell's (1957) work, achieving economic efficiency in production implies the attainment of both technical and allocative efficiencies in production. Thus, the elimination of both technical and allocative inefficiencies is necessary in order to achieve economic efficiency in production. The attainment of economic efficiency in production will lead to gains in productivity. Thus, strengthen the capacity of developing countries who rely heavily on agriculture to alleviate poverty as well as meeting their food needs.

2.3.4. Resource use efficiency

Resource use efficiency refers to the proportion of the Marginal Value Product (MVP) of each input used to their individual costs or Marginal Factor Cost (MFC). The MVP/MFC is an index used to know whether productive resources are efficiently allocated or otherwise. Resources are efficiently allocated when input/output combination would both lie on the production frontier and the expansion borders and MVP is not significantly different from MFC (Danso-Abbeam *et al.*, 2015). That is, a firm would choose assets so that their MVP adequately pays off their MFC. The MVP for each input is obtained by multiplying the Marginal Physical Product (MPP) of each input with the mean price of output. The MFC is the market cost of one unit of each productive input. An input is underutilized if the MVP – MFC ratio is greater than one but overutilized if the ratio is less than one (Haruna *et al.*, 2008; Danso-Abbeam *et al.*, 2015). Olayide and Heady (1982) stressed on allocation of resource in an optimal manner in order to achieve efficiency in production. Optimum efficiency is achieved when it is difficult to reallocate productive inputs without decreasing the total value of output. The important inputs to be considered here are labour and capital since it is possible to alter and reallocate these inputs between farms. The resource-use-efficiency ratio (ER) is computed by dividing the MVP by the MFC for each of the measurable input used. That is;

$$ER = \frac{MVP}{MFC} \qquad 5$$

Where ER is resource-use-efficiency ratio and MFC represent the price of the measurable factor inputs at their geometric means.

Decision rule

i. If *ER*= 1, resources are efficiently used by the farmer.

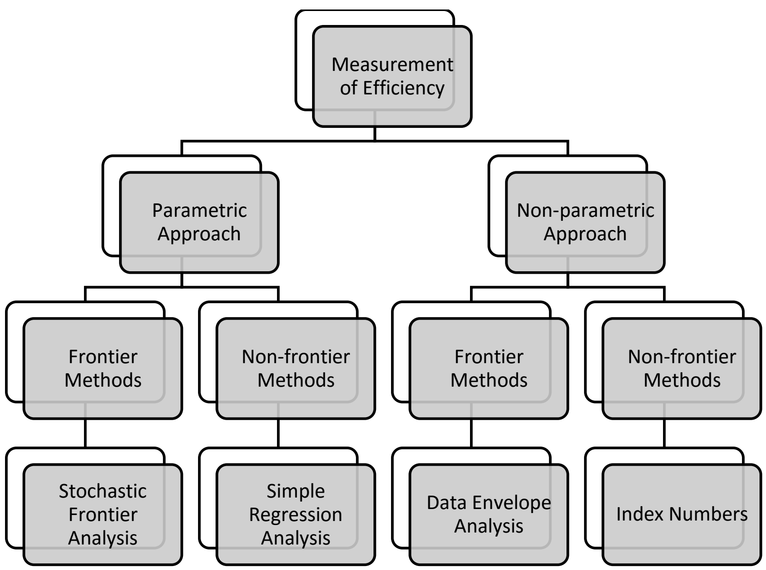
ii. If *ER* <1, resources are over-utilised by the farmer.

iii. If *ER* > 1, resources are under-utilised by the farmer.

2.4 Efficiency measurement

Vasilis (2002) classified the techniques of measuring efficiency into parametric and non-parametric methodologies. He further grouped the parametric methodology into two; frontier and non-frontier methods. The stochastic frontier analysis is one of the frontiers approaches where as simple regression analysis is a non-frontier approach. The non-parametric approach has also been divided into frontier and non-frontier methods. Data Envelopment Analysis (DEA) of non-parametric technique while the index number is a non-frontier method of the technique.

Figure 2.1: Classification of efficiency measurement techniques



Source: Vasilis (2002).

One difference between the two methodologies is the fact that the specification of the functional forms of the production or cost frontier by the parametric methodology which non-parametric methodology does not (Vasilis, 2002). Kumbhakar and

Bhattacharyya (1992) also indicated that econometrics techniques such as the stochastic frontier analysis and simple regression are used when in the parametric approach whereas the non-parametric approach relies on mathematical programming techniques. The most frequently used techniques in measuring agricultural production efficiency are the stochastic frontier analysis and the DEA.

2.4.1 Data envelopment analysis (DEA)

Charne *et al.* (1978) introduced the DEA as a method of estimating efficiency after the original work of Farrell (1957). It has become the basis for successive developments in estimating efficiency through the non-parametric approach since its introduction. It uses mathematical linear programming in which each firm are given weights when they fully benefit from their efficiency scores if only no firm at those weights do not have efficiency scores more than 100% (Charnes et al., 1978; Vasilis, 2002). Firms with efficiency score more than 100% in the set of weights that will make them gain from their relative performance; the solution would be rejected by the model. Each firm has a weight that is different from others and the weights are set in favourable way according to the performance of the firm in comparison with the rest of the firms. Thus, the DEA build up a collection of observations that represents the most efficient in each weight category. In the event that a firm has a score less than 100% at the estimated setoff weight that make best use of its relative efficiency, it is inefficient. For a firm to be inefficient in a set of weights, then there will be at least one efficient firm in the given estimated set of weights. The most efficient firms become mentors that the inefficient ones look up to (Vasilis, 2002).

The major advantage in using the DEA is that, there is no need to have a prior specification of the functional form. Furthermore, one is not required to state the assumption about the distribution of the error term when using DEA (Abatania *et al.*, 2012). However, the DEA has a weakness in that, all deviations from the frontier are attributed to the farmers since they do not consider measurement errors or statistical noise in estimating the efficiency of farmers (Coelli *et al.*, 2005).

2.4.2 Stochastic frontier analysis (SFA)

The stochastic frontier production function model was independently used by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). This model allows for the separation of deviations caused by factors beyond the control of a production unit from deviations caused by the inefficiencies of the production unit. For the deterministic frontier, the random failure of a high number of equipment or even unfavourable weather conditions which may cause deviation from the frontier would be attributed to the firm inefficiency in production. Furthermore, the misspecification of the model or any error in measurement with regards to the variables as well as output could also increase the level of inefficiency of the firm, which is not catered for by the deterministic frontier. The deterministic frontier also holds the view that each firm faces its own production frontier which is arbitrarily set beyond its control. However, the stochastic frontier is able to separate deviation caused by factors which the firm has control over from deviation caused by factors beyond the firm's control such as measurement errors and statistical noise as well as random variations (Battese and Coelli, 1993). In estimating the frontier function for any given sample, the stochastic frontier uses the maximum likelihood technique (Vasilis, 2002).

The ability of the SFA to separate the inefficient component from the deviation caused by random disturbance terms such as weather, measurement errors and statistical noise is a key strength of the approach. This therefore allows for the making of separate assumptions with regards to the error component and the distribution of the inefficiency resulting in precise measurement of relative inefficiency (Farrell, 1957; Batttese and Coelli, 1993). Nevertheless, there is a weakness in using the stochastic frontier model since there is no prior explanation for the choice of the specific distributional form for the inefficient component of the error term (Greene, 1990).

2.4.3 Review of empirical application of SFA and MVP/MFC ratio

There has been increase concentration in measuring agricultural production efficiency in Africa decades after the famous Schultz 1964's work of the "poor but efficient" hypothesis. Several researchers have endeavored to contribute to the knowledge of efficiency of food crops production in a bid to increase productivity of agricultural output to meet the growing food demand in Ghana.

Several researchers have applied the SFA and MVP/MFC Ratio in their work on efficiency of the agricultural sector in Ghana. Donkoh *et al.* (2013) applied the stochastic frontier analysis to estimate technical efficiency of rice farmers in the Upper East Region of Ghana and had a mean technical efficiency score of 81%. Yiadom-Boakye *et al.* (2013) similarly employed the Cobb-Douglas stochastic frontier analysis to examine gender effects of resource use and technical efficiency of rice farms in the Ashanti Region of Ghana. Women were found to be highly inefficient in rice production compared to their male counterparts. They also had a low overall average technical efficiency score of 24%. Aneani *et al.,* (2011) determined resource use efficiency in cocoa production in Ghana and found incidence of wastefulness by farmers in managing cocoa resources during production periods. They revealed that resources such as insecticides, fertilizer and fungicides were underutilised with their respective efficiency ratios greater than one whiles land was over utilised with an efficiency ratio less than one. Equally, Nimoh and Asuming-Brempong (2012) who estimated resource use efficiency for cowpea cultivation in Akatsi district found that all resources were over-utilised since the efficiency ratios of all the inputs were less than one. This implies inefficiency in the use of these resources in cowpea production.

Danso-Abbeam *et al.* (2015) also indicated inefficiencies in the use of available resources in their study of resource use efficiency among smallholder groundnut farmers in northern Ghana. Their study found that labour and seed were overutilised inputs whiles herbicides usage was underutilised since it was expensive in the region. Awunyo-Vitor *et al.,* (2016) examined the efficiency of resource use among maize farmers in Ghana and reported inefficiencies in the use of all resources available to farmers which is seen in the underutilisation of fertilizer, manure herbicides, seed, pesticides and land while labour and capital were overutilised.

2.5., Market, origin, and distribution of onion

The market for onion is huge in the era of globalization and trade liberalization. The market for onion witness an increase in volume of onion trade among countries to the tune 6.6 million tons representing 4.6% growth rate in 2018 (Aleksandr, 2019). Onion with the botanical name *Allium* Cepa L. of the family of Alliaceae is believed to be among the oldest and important vegetables still being cultivated throughout the world (Boyhan & Torrance, 2001; Muhammad, 2008). The origin of onions is not very clear, as wild forms of the crop have not yet been identified at any specific place (Boyhan & Torrance, 2001). Adam (2006) states that onions are currently thought to have started from Southwest Asia, however no wild progenitor has been found so far in that place. Grubben and Denton (2004) associates the origin of alliums to Iran where the closely related *Allium* Vavilovii and *Allium* asarense species are found. Boyhan and Torrance (2001) also believe that the centre of origin of the crop can be traced to Afghanistan and its surrounding regions.

Onions are produced commercially in at least 175 countries throughout the world. FAO statistics (FAO, 2016) indicate that the crop occupies the fourth place in world production of vegetables, with a volume of 93 million tons and an estimated 4.96 million hectares of land area used for its cultivation worldwide. FAO also identified the top producers of onion in the world to be China, India, Australia, United States of America (USA), Turkey, Pakistan, Russia, South Korea, Japan and Spain. The highest onion producing countries in Sub-Saharan Africa (SSA) are said to be Nigeria, South Africa, Niger, Senegal and Mali. Niger is noted to be the third leading onion producer in Sub- Saharan Africa, delivering about 270,000 metric tons per year, and is the primary supplier of onions to consumer markets in the sub-region (FAO, 2016). La Cote d'Ivoire, Ghana, Benin, Burkina Faso and Togo are some of the countries importing onion from Niger (Muhammad, 2008; DAI, 2014).

2.6 Production of onion in Ghana

Ghana is ranked 57th in terms of onion production in the world with 0.02% share of the world output of onion and 13th largest producer in Africa. Ghana output of onion stood at 143,982 tons using about 8,420 hectares of land for its cultivation (FAO, 2016). The savannah belt where Upper East Region is located alone accounts for about 85% of Ghana's output (DAI, 2014). The Bawku Municipality, Pusiga, Binduri, Garu-Tempane and Bawku West Districts are the main production areas in the Upper East Region (MOFA, 2015).

Table 2.1: Onion output and productivity in Ghana between 2010 – 2017

Year	Output (Tons)	Cultivated Area (Hectares)	Productivity (TONS)
2010	100,000	7000	14.28
2011	120,000	7500	16.00
2012	130,000	8000	16.25
2013	138,188	8300	16.65
2014	143,982	8420	17.10
2015	143,982	8420	17.10
2016	143,982	8420	17.10
2017	145,156	8314	17.46

SOURCE: FAOSTAT (2018)

The Region has the production potential and favourable environmental conditions for the cultivation of the vegetable. The cool dry climate conditions during the harmattan season and the presence of irrigation facilities and natural water sources such as the White Volta makes irrigation farming particularly onion production a profitable venture in the region. The Bawku Red, the predominant variety in Ghana, was introduced into the country around 1930 and was first grown at Bugri, a suburb in the then Garu-Tempane District (Sinnadurai & Abu, 1977; MOFA, 2006).

2.7 Economic importance of onion production

Onion is an important commercial and cash bulb crop which farmers and other players along its value chain can enormously earn enough income from its cultivation and processing. The commercial production of onions is gaining considerable importance across Ghana, especially in the Upper East region as more farmers across all the administrative districts and municipalities are becoming familiar with the crop. Until recently, onions were produced largely in the Bawku traditional area where the crop is regarded as the "the cocoa of Bawku".

Onion cultivation has become a popular alternative to the commonly cultivated tomato. Farmers in the other districts cultivated mostly tomato on large scale and other vegetables on very small scale. However, the numerous challenges associated with the cultivation of tomatoes in Ghana such as perishability, diseases and pest and inadequate marketing opportunities (Clottey *et al.*, 2009), have made some of the farmers to include onion farming as an alternative and to reduce their long run income risks. Whereas tomato farmers cannot store their produce during the peak season even when the prices are not good for them, onions when stored under the recommended temperature, humidity and other environmental factors can be kept for more than five months. This gives onion farmers an advantage over other vegetables as they have control over the sale of their produce.

The crop is often regarded as a security crop since it is mostly cultivated in the off-season. Its cultivation in the dry season help farmers and other actors to earn income enabling them to acquire their basic needs, buy inputs for the major season and small ruminants for rearing, construct and maintain housing structures as well as pay school fees, health bills, dowry, welfare contribution thus increasing household resilience to poverty and food insecurity.

Cultivation of onion creates employment to farmers including women and the youth (as hired labour), input dealers, wholesalers, retailers, carters and transporters and traders who are mainly dominated by women and so its contribution to the economy of Ghana cannot be overemphasized. The ministry of Food and Agriculture (MOFA) reports a reduction in rural-urban migration in the communities producing onion due to the cultivation of the crop in the dry season which is the period of migration for most farmers from the north to the south of Ghana to search for jobs (DAI, 2014).

2.8 Resources in onion production

2.8.1 Land

The most essential productive resource in rural economies is land (FAO, 1997). In agriculture, land is generally regarded as an important natural resource and an essential input for the improvement of subsistence agriculture. In most Sub-Saharan countries, the productive capacity of land is generally decreasing due the loss of soil fertility and is aggravated by the relative scarcity of land for agricultural production due the rise of urbanisation. Therefore, there is need to bring virgin lands under cultivation which comes at high cost due to long distance. Farmers would not invest heavily in these virgin lands except that they are certain about the benefits of their investment.

Land in Ghana is vested in the hands of communities or clans or family heads. Ownership of land is therefore mostly based on a system of inheritance, which leads to fragmentation of farm holdings. La-Anyane (1969) observed that this particular characteristic of the land tenure system in Ghana is a hindrance to agricultural production because the continuous fragmentation of holdings into smaller farm sizes prevents the enjoyment of economies of scale. Nurah (1999) noted that land acquisition for vegetable production in the country is not a problem for farmers during the raining season where vegetables are cultivated on the same piece of land with other crops. He however, observed that the cultivation of vegetable on large scale for commercial purposes, especially in the dry season has accordingly led to an increase in more commercial arrangement for renting land.

2.8.2 Labour

Beside land, labour is another indispensable resource in the cultivation of vegetables. Approximately 75% household units in the country are considered to be agricultural households, comprising about 90% in the guinea savannah zones, 65% in the forest zone and 50% in the coastal savannah zone (GSS, 2017).

Kamga *et al.* (2016) noted that onion cultivation requires the use of a lot of workers and several farmers with small farm size depends on family members for labour, which often compete with other activities of family members. Most farmers consequently make use of hired labour to complement family labour if their farm size is large.

2.8.3 Capital

Onion production is capital intensive; farm implements, irrigation equipment, agro-chemicals as well as harvesting among others. Arsanti and Bohme (2008) stated the various means of securing capital for farming as personal savings, donations, inheritance, borrowing, leasing and contract farming. Akudugu *et al.* (2012) mentioned that inadequate capital and credit facilities derailed the likelihood of input substitution (for example. weedicide for labour intensive tasks). This may in the long run affect the productivity of the farmer (Jansen *et al.*, 1994; Kibaara, 2005).

2.8.4 Water

Agricultural production in Ghana largely depends on rainfall to water the crops but rainfall patterns are not evenly distributed in the country and not reliable especially in the North which may directly affects crop production. Farmers in Ghana use irrigation to increase production levels of crops including vegetables (Boateng *et al.*, 2016). Namara *et al.* (2010) broadly classified irrigation in to; conventional irrigation systems comprising public surface wastewater, shallow ground water, small reservoir and residual moisture irrigation and emerging irrigation systems covering groundwater irrigation using water lifting technologies such as water pumps as well as private small reservoirs. However, there is limited support for irrigation in the country, especially small-scale farmers using informal irrigation (Dittoh *et al.,* 2014).

2.9 Determinants of agricultural productivity and efficiency

2.9.1 Production factors

This part deals with a review of research works on factors affecting onion production. These factors are the conventional inputs that influence production of onion. They include land, onion seed, labour, capital, application of fertilizer and weedicides/pesticides.

2.9.1.1 Farm size

Agricultural production including onion cultivation largely depend land for growth and success. The acquisition of land for commercial agriculture is difficulty due land tenure systems and unattractive land tenancy agreements. This has often caused farmers to devote a small portion land for vegetable production including onion as noted by Anik and Salam (2015). Land fragmentation is one of the causes of onion farmers' inefficiency but increasing the size of land would increase the output of onion since land has a positive estimated elasticity value (Baree, 2012). Dossah and Mohammed (2016) also stated that farm size has a considerable positive relationship with the output of onion in Nigeria. Similarly, Kamga *et al.,* (2016) had recognized a substantial positive correlation between onion output and farm size, which may imply that expanding the farm size will result in an increase in onion output.

2.9.1.2 Onion seed

The release and cultivation of high yielding seeds had resulted in tremendous improvement in output level of most crops in Ghana. The use of improved onion varieties can contribute to increasing onion productivity (Akrofi *et al.,* 2016). Rajendran *et al.,* (2016) found a substantial positive influence by seed on vegetable output implying that the use of more quantity of seed in production will result in an increase in output of vegetables. Mainga *et al.,* (2015) also disclosed that farmers in Swaziland who used improved vegetables seed obtained higher yield than those who used the local variety of seed. Other works have also found the use of improved crop seed to be positively related to productivity in agriculture (Tanko & Obalola, 2013; DAI, 2014; Abdulai *et al.*, 2017).

2.9.1.3 Labour

Labour is an important productive input in the cultivation of crop in Ghana especially onion production. Onion production in Ghana is labour intensive because labour is needed to prepare beds, seedlings, weeding, fertilizer and pesticides application, harvesting and transportation (DAI, 2014). Most empirical studies (Shemitte *et al.*, 2015; Anik *et al.*, 2017; Kantariya *et al.*, 2018) used person-days as a proxy to measure labour which is mostly classified as family labour, communal labour and hired labour. The use of family members and friends/peer groups in the farm without paying them a daily wage is considered to be family and communal labour respectively. Hired labour refers to those that the farmer pays for their efforts in the farm before work or at the end of work. Empirical evidences prove the existence of a positive influence of labour on the output of agricultural production. For instance, Shemitte *et al.,* (2015) found a labour has a great positive influence on onion production.

2.9.1.4 Capital

Capital is a vital input when it comes to the cultivation and management activities of onion farms. The onion farmer needs farm implements for tilting the land, irrigating the crops, spraying agro-chemicals for protection as well as buying farm inputs and paying for the services of hired labour and all these activities depend on the capital available to the farmer. (Anim *et al.,* 2015).

Kamga *et al.,* (2016) also argued that the inability of farmers to adopt capital intensive methods of production or adopt modern technologies in farming is due to the inadequate capital and limited access to credit facilities. Access to credit by farmers has a significant influence on farmers' adoption on improved varieties of onion (Anik & Salam, 2016). Empirical evidences by Baree (2012) and Rajendran *et al.,* (2015) also confirm the positive relationship between capital and the output of onion farmers.

2.9.1.5 Fertilizer application

The continues use of land for agricultural cultivation with little or no fertilizer and manure had led to a decrease in soil fertility (Boateng *et al.,* 2016). Farmers in a favourable environment usually apply chemical fertilizer if they want to maximize the gain in onion production (Hossain *et al.,* 2017). However, access to fertilizers and affordability by onion farmers remain a challenge in Ghana due to cultivation of the crop mostly in dry season (DAI, 2014). Productivity of onion can be improved if farmers apply the right quantity of fertilizer and in time. For example, Rajendran *et al.*

(2015) found fertilizer usage to be one of the inputs having a higher elasticity of output. Also, Dossah and Mohammed (2016) found fertilizer usage to have a positive influence on the output of vegetables indicating that applying right quantity of fertilizer to vegetable farms will lead to an increase in output.

2.9.1.6 Pesticides application

Pests and diseases attack are regarded by farmers as one of the factors contributing to low output and crop failure. Akrofi *et al*. (2016) stated that farmers use agrochemical as an effective means to control foliar and bulb diseases as well as insect pest in Ghana. Haile *et al.* (2016) stated that the use of agrochemicals such as pesticides positively influence the output of onion.

2.9.2 Inefficiency factors

The difference in output of farmers can be attributed to socio-economic and institutional features of farmers. These factors can contribute to farmers' inefficiency and so are of interest to policy makers in their quest to improve agricultural production. From empirical studies, the following were found to have relations to efficiency.

2.9.2.1 Gender

Gender plays a role in promoting agricultural production (Rola-Rubzens *et al*., 2016). For example, Malinga *et al.* (2015) found that male farmers are more inefficient in the cultivation of pepper compared to their female counterparts. Yiadom *et al.*, (2010) on the other found women farmers to be inefficient relative to their male counterpart in terms of rice production.

2.9.2.2 Age

Akudugu *et al.* (2012) highlighted the significant role of age in agricultural activities in the area of decision making, adoption of improved farming practices and management of labour and other production related activities. Researchers have varied opinions based on their works on the relationship between age and inefficiency of farmers. Baree, (2012) and Haile, (2015) claimed that age can be used to represent the experience of the farmer and that farmers who are old have more experienced in farming and efficient in the use of productive resources than the more youthful farmers. For instance, Haile (2015) observed that age had a significant negative impact on inefficiency. The evidence of their studies shows that old and experienced farmers are more efficient than young and inexperienced farmers. They considered the likelihood of older farmers having more contacts with extension agents and selecting the good farming practices after attempting several of these practices to be factors responsible for this outcome. On the other hand, Asogwa *et al.*, (2012) and Umeze, (2015) believed that the more youthful farmers are more efficient than very old farmers because of the willing of young farmers to adopt new technologies that can increase output levels. For instance, Umeze (2015) found a positive relationship between age and inefficiency of farmers since older farmers are less dynamic and will not readily respond favourably to agricultural innovations resulting in routines production practices.

2.9.2.3 Education

Farmers are able to have access to external sources of agricultural information or acquire agricultural skills and knowledge on new technology through education

(Dossah & Mohammed, 2016). Shettima *et al.* (2015) affirmed that formal schooling affords the farmer the opportunity to learn new farm technologies easily. Karthick, *et al.* (2015) argued that education could lead to an increase in the efficiency of onion farmers because of its positive relationship with onion output thereby reducing the degree of inefficiency. Abdu *et al.* (2015) also revealed that education has a positive influence on the technical efficiency of onion farmers. They further stated that education help to enhance farmers ability to acquire and utilized improved agricultural technologies including entrepreneurship knowledge. Baree (2012) however, found education to negatively influence technical efficiency. He explained that educated farmers might be using uneducated farm labourers on their farms due to an increase in their non-farm activities that may have substantial returns.

2.9.2.4 Access to credit

Access to credit has been proven empirically by researchers to have a significant influence on efficiency of farmers. Farmers who are not able to obtained credit are usually constrained in their farm operations (Ansah *et al*., 2016) and this could affect their efficiency level. It is in this light that Donkoh *et al*. (2013) advocates for small holder farmers to be supported to access credit which will enable them to join the modernization drive in order to boost agriculture output and efficiency. Alhanssan (2012) found that access to credit facilities have great influence on the efficiency of rice farmers in the Upper East Region of Ghana.

2.9.2.5 Use of water pumping machine

Depending on the topography of the irrigated area and source of water, water is often distributed via the use of pumping machines, gravity or both. Some decades ago, farmers could only use buckets and watering cans to get water across to their farms in the dry season from available water source, be it a dam, river or dugout when gravity cannot support the water distribution to their farms. This method of water distribution was tedious and required more labourers to be effective. The introduction of motorised water pumps for water application is making the use of buckets and watering cans to be out of favour, especially when farmers have plans to expand their farm sizes to gain more income. Kibaara (2005) stated that the introduction of mechanization in farm operations is a significant step in an effort to improve efficiency of farmers.

2.9.2.6 Farm size

Many researchers have identified farm sizes to be among the factors that have a significant influence on productivity and efficiency. Lau and Yotopolous (1971) stated that small size holders are more productive than larger farm size holders in India using a profit function equation. Using a stochastic frontier analysis, Adzawla *et al.* (2015) also found that small farm size holders were less inefficient than those who hold large farm sizes. On the contrary, Sahidu (1974) who used the Lau – Yotopolous model in studying India wheat farms concluded that there is no difference in the level of productivity between small and large farm size holders. Also, Khan and Maki (1979) adopted the Lau – Yotopolous model in Pakistan but found large farm size holders being efficient than small farm holders.

2.9.2.7 Farming experience

Experience in farming is another important factor that can influence the efficiency of farmers. A farmer gains a lot of experience as he/she spends many years in farming. Thus, farmers who have long history of farming experience are likely to be more efficient than those with short history of farming experience. Farming experience is expected to impact positively in the production decision-making. It is believed that the more experienced farmers are better informed in their production decisions regarding their activities since they are able to bring their years of experience to bear on their managerial decision making. Consequently, farming experience may be used as a substitute for managerial expertise in agricultural production.

2.9.2.8 Access to extension service

Poor extension service delivery in developing countries has been recognized as one of the causes of the gap that exists between actual output and potential output (Seidu, 2012). Tanko and Obalola, (2013) found a substantial positive relationship between access to extension and efficiency of onion farmers. According to Abdu *et al.,* (2015), farmers who access to extension services have a high level of adoption of improve and advanced technologies in onion production from preparation of land to harvesting of the crop. Easy accessibility of extension services by farmers thus enables them to improve their productivity leading to a reduction in their inefficiency levels. Works by other researchers prove that access to extension has a positive influence on productivity and efficiency in agriculture (Ojo *et al.,* 2009; Sanyang, 2014; Dossah & Mohammed, 2016; Kamga *et al.*, 2016).

2.10 Challenges facing the onion industry

Despite the abundant resources for the production of onions and the support provided by Government and Non-Governmental Organisations (NGOs) in the country, there exist demand surplus in Ghana which is met through importation from other nearby countries (DAI, 2014; Gonzalez *et al.*, 2016). Ghana's Ministry of Food and Agriculture also indicates that onions are predominantly cultivated in the northern part of the country.

The onion industry in Ghana faces several challenges along the value chain that makes it difficult for the country to meet its domestic demand for onion. These challenges seem to be the same or similar across the globe and can be classified under two headings as production related challenges and market related challenges. Among the production related challenges are difficulty in getting access to production inputs, diseases and pests management, inadequate technical ability, irrigation and inadequate institutional capacity (Akrofi *et al.*, 2016). Farmers' access to inputs can be viewed in two dimensions; in terms of the availability of the inputs on the market and whether the farmers can afford to buy them. In some instances, the inputs are not available for farmers to buy and in other cases they may be available but very expensive for a subsistent farmer. For instance, Haile *et al.* (2016) reports that constraints of onion farmers in Southwestern Ethiopia included high cost of inputs and scarcity of the inputs such as pesticides. Clottey *et al.* (2009) identifies the constraints of vegetable farmers in the irrigation facilities in the Upper East Region of Ghana as high rent for land, poor quality of seed, high cost of mechanisation, water charges and high cost of agricultural inputs such as fertilizer, seed and pesticides. Related to this is the high cost of irrigation. Since onion is cultivated in the dry season, farmers use a great deal of their time and energy to supply water to the crop throughout the production cycle. Where well-developed irrigation facilities are available, farmers are unable to meet the high-water usage charges. In some instances, farmers use petrol powered pumping machines which also results in high expense on fuel and maintenance of pumping machine which have a considerable impact on the efficiency of onion farmers.

Vegetable farmers also face the great challenge of high incidence of pests and diseases. Kamga *et al.* (2016) attributed poor yield and low quality of onion produced by some farmers to the effects of diseases attacking onion farms. Akrofi *et al.* (2016) stated that onion diseases could occur in the seedbed, production field and/or in storage. Adam (2006) also notes that diseases and insect attacks as well as weeds can greatly affect the output of onion negatively. With increased campaign on sustainability and environmental consciousness, a great challenge in onion production currently is how to produce the vegetable in a sustainable and environmentally friendly manner with the use of agro-chemicals to improve yield and output without destroying the environment. Some onion farmers do not also have the adequate knowledge in handling some technical production techniques. These include the lack of adequate knowledge in pest and disease management, use of fertilizers, irrigation and water management and selection as well as use of improved onion varieties. Farmers, especially in developing countries are not properly organised to be able to take advantage of group solidarity. Whereas developed countries such as the USA have National Onion Associations (NOA), African countries do not have well organised associations. The non-existence of vibrant national producer associations makes it extremely difficult for farmers to have a strong say in decisions taken concerning the production, marketing and formulation of policies that affect them. According to Clottey *et al.* (2009), some farmers in Ghana could not access credit from the Social Investment Fund (SIF) or some financial institutions because they were not organized as groups or cooperatives that would provide collective collateral security for group lending.

Market access is among the greatest challenges facing farmers with small farm size especially in developing countries (Langyintuo, 2005). The situation is even serious when it concerns perishable products such as vegetables. Some of the specific marketing challenges in the onion industry are high post-harvest losses as a result of inadequate storage facilities, poor road network and inadequate market information on prices at the destination markets, lack of strong market associations due to the lack of transparency within the players and poor grading and packaging. Hjelm and Dasori (2012) reports that farmers in Ghana incur post-harvest losses of up to 50 percent due to inadequate facilities for storing and drying vegetables.

Onion farmers in Ghana, according to DAI (2014) also lack improved or scientific storage facilities to help them hold the onion for some time so that they can also get good market prices. This is as a result of poor storage conditions. Like most agricultural products, the price of onion is often very low at the harvesting time. Therefore, onion producers make very little or no profits when they sell their onions just after harvesting. The ideal situation will be to store them for at least three months when prices would have increased. However, farmers do not have the adequate know-how to store their produce. Other factors that affect the storability of onions are temperature, humidity, maturity of the bulbs, the use of high nitrogenous fertilizers, injuries during harvesting, the amount of water and the presence of pest and diseases.

Transportation of onions from the production centres to the market centres is also a great challenge to farmers (Kamga *et al.,* 2016). Onions are produced in remote areas that are not easily accessible due to the poor nature of the roads. The onions therefore stay very long in transport, especially when vehicles breakdown. When this happens, the onions are exposed to adverse weather and spoilage of the crop before it gets to the market.

2.11 Summary and conclusion

The review of literature clearly shows that several methods have been used to measure the productivity and efficiency of agricultural production. The methods include the non-parametric approaches (example, DEA) and parametric approaches (such as SFA) (Vasilli, 2002; Abatania *et al*., 2012; Abdulai *et al.,* 2017). Generally, the review of literature also reveals low-level efficiency of crop production in several developing countries with Ghana not an exception. Also, studies that have been conducted on onion productivity performance have showed technical efficiency in onion production is low compared with efficiency in the production of other crops. It is important to investigate its efficiency level in the country since onion has numerous uses in food preparation and can be exported if the domestic demand is met to boost the development of the country. At the production level, it is important to measure technical, allocative and economic efficiencies as well as resource use efficiency with the goal to empower onion farmers to be competitive. It is also important to identify the factors that determine the efficiency of onion production and to find ways of improving the efficiency of onion production.

The study therefore seeks to address those above-mentioned characteristics associated with onion cultivation in the study area, so as to present a complete description of the sector from which policies can be drawn for the development of the sector and the economy of Ghana.

This current study will therefore add to the existing literature in several ways: Firstly, this study will help in bridging the literature gap in onion production which has been under-researched in the country as compared with other vegetables. Besides, even with the fact that onion production is one of the major cash vegetables cultivated in the region, especially in the dry season, it remained under-researched in the region and no work has covered efficiency measurement of onion production in Ghana which would be addressed with this study. Thirdly, although some empirical studies have dealt with technical efficiency analysis of crops production (Donkoh *et al.*, 2013; Danso-abbeam *et al.*, 2015; Abdulai *et al.*, 2017) and some work has been done on agronomic practices of onion production in the country (Akrofi *et al.*, 2016), none have covered efficiency measurement of onion production in the region. In conclusion, this study will provide policy makers with evidence to aid them formulate policies that lead to the improvement in the efficiency of onion farmers in the region and other parts of the country.

CHAPTER THREE

METHODOLOGY

3.1 The study area

Figure 3.1: Map of Ghana

Source: ghanamaps.com (2019)

The Upper East Region is among the smallest regions in the country in terms of land size. The region occupies a land area of about 8,842 square kilometers representing 2.7% of the total land of Ghana with approximately 1,046,545 people representing 4.2% of the total population of the country (GSS 2013). The region is located in the north-eastern corner of the county (Sky blue boundary in Figure 3.1) stretching from longitude 0°11' to 1°W and latitude 10°30'N to 11°11'N.

The region shares borders with Togo to the East, Burkina Faso to the North, Upper West Region to the West and North East Region to the South. Bolgatanga (often called 'Bolga') is the regional capital but other prominent towns include Bawku, Navrongo, Paga, Sandema, Garu, Pusiga and Zebila. The region now has fifteen (15) administrative Municipal/District Assemblies with the inauguration of the Tempane (Carved out of the Garu-Tempane District) and the Bolgatanga East (Carved out of the Bolgatanga Municipality) Districts (Citifmonline, 2018).

The region lies in the Guinea savannah agro-ecological zone with a moderately flat land and few hills in the east and southern corners. The fertility of the soil is low due to low organic matter content with a course soil texture (GSS, 2013). The vegetation of the region is mainly savannah woodland with few short-scattered drought resistant trees. In terms of rain-fall, the region enjoys two (2) season; rainy season and dry season. The region enjoys the rainy season from late April to early October with a yearly mean precipitation of about 921mm. The region receives a minimum of 645mm and a maximum of 1250mm of rainfall. The rainfall is erratic with August recording the heaviest precipitation of about 253mm. The cultivation of cereals and legumes with vegetables are the main farming activities, which solely depends on rain-fall. The dry season in the region begins in early November and ends in April. During this period, the region experiences low humidity and dry harmattan winds. The region is usually very hot, warm and dry around this season with temperature ranging from a minimum of 15° C (around November to February) to a maximum of 45° C (around March to April). The low humidity couple with the temperature ranges makes the area suitable for the cultivation of horticultural crop such tomato, onion, pepper, okro, watermelon and other leafy vegetables (MOFA, 2013). The White Volta and Sissili rivers are the main rivers of the region with Tono and Vea dams being the two major irrigations dams in the region.

The major occupation in the region is agriculture, particularly production of crops such as rice, maize, millet, sorghum, ground nut and beans in commercial quantities in the rainy season and vegetables in commercial quantities in the dry season. Moreover, the people in the region rear large number of animals like cattle, sheep and goat beside engaging poultry, rabbit and piggery production to supplement their incomes. About 84% of households are engaged in agricultural activities in the region (MOFA, 2016). The major areas by percentage of workers in the region are; agriculture and related work (70.5%), craft/equipment production and related work (11.9%), sales work (9.7%) management and service work (3.9%), and professional technicians and related work (4%) (GSS, 2013). This study focused on onion production which is among the major cash and vegetable crop cultivated in the Upper East Region in the dry season.

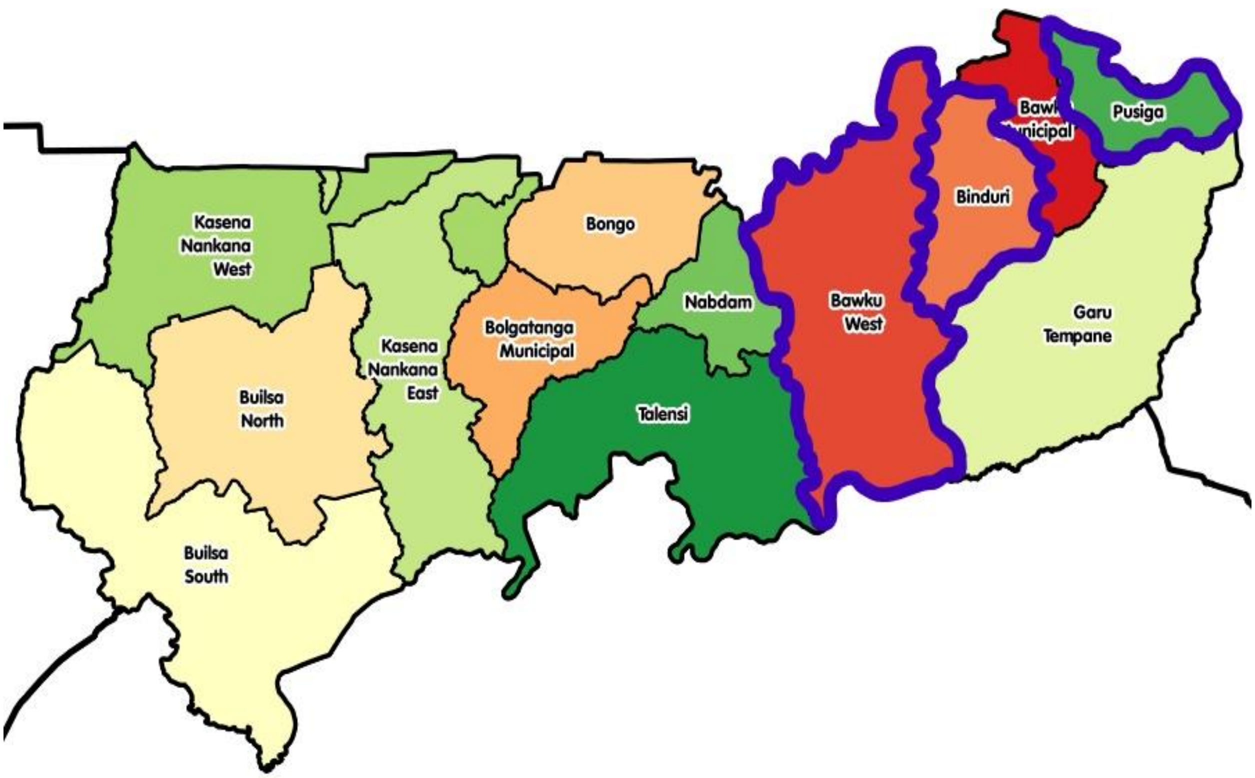
3.2 Sampling

Multi-stage sampling technique was used for the study. In the first stage, the districts in the region were stratified into notable onion producing districts (Tempane, Pusiga, Garu, Binduri, Bawku West and Bawku) and non-onion producing districts. Bawku

West, Binduri and Pusiga districts (Blue boundaries in Figure 3.2) were randomly selected from the onion producing districts for the study.

In the second stage, the communities in the chosen districts were stratified based on the intensity of onion cultivation with the help of staffs of the agricultural departments in those districts and the required number randomly sampled from the stratum of communities with intense onion production. In all, a total number of 272 onion farmers regardless of acreage were randomly selected in the region for the study.

Figure 3.2 Map of Upper East Region



Source: www.google maps, 2018

Table 3.1: Selection of onion farmers in the study area

District	Town/Community	Sample of onion farmers
Bawku West	Zebilla Natinga, Kobore, Sapelliga, Googo, Galinka, Yarugu, Akaribut, Teogo, Salpiige	85
Binduri,	Bazua, Yalum, Bayalum, Yalumgu, Yalugu, Beeka	87
Pusiga,	Tindaadi, Widana, Kopella, Kolpelin, Kayikm, Pusiga, Zuabuluga, Mandago, Tedako	100

.3.3 Data collection

The data used for the study were cross sectional data collected through a field survey from 13th August to 29th September 2018 using semi-structured questionnaires, facilitated by field enumerators and key informant interviews in the month of December, 2018.

3.4 Analytical framework

The study uses both descriptive and inferential statistics during the analysis of the data. Descriptive statistics such as mean, frequencies distribution and percentages were used to present results on the socio-economic characteristics of onion farmers. The stochastic frontier production regression was used to achieved objective 1 and a component of objective 2 (technical efficiency), stochastic frontier cost model was used to achieved the allocative efficiency component of objective 2 while the remaining component of objective 2 (economic efficiency) was achieved by the product of the stochastic frontier production function and the stochastic frontier cost model. The Z-test was used to test for the significant differences in the mean efficiencies of water pump users and non-water pump users in onion cultivation while the resource use efficiency ratio was used to achieve objective 4. Finally, objective 5 was achieved through ranking of onion production constraints.

3.4.1 Theory of production

The theory of production in economics is the foundation for most empirical studies of productivity and efficiency. The production process is generally defined as an input – output process microeconomics. Classical microeconomics generally defined the production process in terms of an input- output process. A production generally is an art of transforming productive factors into outputs with a given level of technology. A producer's capacity to transform inputs into feasible outputs is principally dependent on the available technology referred to as technological feasibility. A production function requires an input function denoted by $X = (x_1 \dots \dots \dots \dots x_n)$ for a set of real numbers R_n, to produce an output denoted by the function $Y = (y_1 \dots \dots \dots y_m)$ for a set of real numbers R_m. Therefore, a production possibility can be defined as the subset of production space, which is given by R^{m+n}.

The rationale for production is mostly dominated by profit maximization although economists have found other minor reasons for production such as cost, prestige and market shares (Battese & Coelli, 1995). Production units (firms) will choose a set of various inputs with a level of technology to produce a vector of output as its production plan in order to achieve profit maximisation since that is the main goal of production although is it also guided by cost minimisation. The production set of a firm is defined by the combination of the vector of inputs and technology for producing feasible outputs. The vector of inputs and the level of technology of a firm available will constitute the set of feasible outputs that may be produced from the combination of the existing production inputs and technology, which may restrict the profit maximisation objective.

3.4.2 The production frontier and productive efficiency

The concept of production frontiers is well espoused in most classic textbooks on microeconomics (Varian, 2010; Debentin, 2012). These books have often treated production within the context of scale economies. In the illustration of the concept of production frontier, an important assumption that arises, a firm produces a single output Y using a set of n-dimensional vector of inputs X and a specified level of technology. If we further assume that the production possibility satisfies the condition $(x, y) \geq 0$, then a more general specification of the frontier technology will be given as:

$$y = f\ (x) \qquad 1$$

Then the function is the production frontier and will give the upper boundary of T (Debentin, 2012). If the production frontier is further assumed to be in an output maximizing form, then the production frontier can be expressed as;

$$f(x) = max\{y : T(x, y) \geq 0\} \qquad 2$$

The production frontier function then becomes the standard to which measures of efficiency (technical and allocative) of production can be compared. The frontier therefore must contain only the efficient output (observations) of the production unit. The analysis of production frontier is crucial if we are to increase the level of output in any production process. The analysis of frontier measurements has largely been focused on scale economies, which form a general property of production units. Thus, a change in the quantity of the variable factor used in production will result in a change in the proportion of fixed and variable factors in the production process.

Returns to variable proportion refer the responsiveness of the output to changes in fixed and variable inputs. In effect, a firm can vary all its variable factors and of the ways to measure the degree of the responsiveness of output to these variations in production is to use the returns to scale. Therefore, return to scale can be defined as the degree of responsiveness of output to the variation of all inputs in the same proportion. Returns to scale are classified into increasing returns to scale (IRS), constant returns to scale (CRS) and decreasing returns to scale (DRS).

Productive efficiency implies the achievement of production targets without wasting resources or input used. Researchers in economics have been able to develop a lot of theories about efficiency from knowledge of making maximum use of resources in production. All these theories have to do with the quantity of output produced per one unit of input used in production. Production inefficiency is estimated by the level of deviation from the production frontier that represents the best practiced technology observed from all production units. Therefore, inefficiency exist when a given set of inputs are used to produce fewer quantity of output than can be obtained. The classical approach and the frontier approach are the two fundamental techniques used in measuring efficiency of agricultural production.

3.5 Theoretical framework

The frontier function method is used to measure the inefficiency of individual producers. Working independently, Arigner *et al*. (1977) and Meeusen and Van de Broeck (1977) concurrently proposed the stochastic frontier production frontier. It applies the Cobb – Douglas production function to simultaneously estimate the random disturbance term and the inefficiency effect as proposed by Battese *et al.*, (1996). Besides, the technique is consistent with most of the agricultural production efficiency studies (Coelli, 1995; Olarinde *et al.*, 2008).

Several studies have applied the stochastic frontier model in applied economics research to measure the efficiency of production units. Both panel and cross-sectional data have often been used for this purpose. Considerable work in the literature also shows an extensive use of panel data in measuring production efficiency (Battese and Coelli, 1995). Extensive work has also been carried out using cross-sectional data in efficiency measurements. Studies by Donkoh and Awuni (2013), Danso-Abbeam *et al.*, (2015), Abdulai *et al.*, (2017) and others on efficiency were carried out within the framework of cross-sectional datasets and applied the stochastic frontier models thereof by specifying appropriate functional forms. Battese and Coelli (1995) specified their function as:

$$ln(y_i) = f(X_i : \beta) + v_i - u_i \quad 3$$

$$u_i = \delta_i Z_i + \omega_i \quad 4$$

The above equations represent the stochastic frontier function and the efficiency model where y_i represent the output produced in natural logarithm of the i^{th} firm, X_i represent the vector of known inputs used in the production function which are associated with the i^{th} firm and β refers to the vector of unnamed parameters to be estimated in the given specified production function. The 'composed' error terms made up of the statistical and inefficiency components are distributed independently of each other. u_i is assumed as the set of non-negative random variables with a firm specific technical inefficiency of the production.

According to the Battese and Coelli (1995) specification, the inefficiency term u_i in the production process, presumed to be independently distributed, is obtained by the zero truncation of the normal distribution with mean $Z_i\,\delta$ and varianceδ^2. In their specification of the inefficiency model however, Battese and Coelli (1995) assumed there are certain independent variables that affects efficiency and these may include some parameters, which are contained in the specified frontier production function provided these inefficiency effects are stochastic. In their estimation of the time varying inefficiency effect, they proposed that if the first value of the estimated coefficients in the inefficiency model was one and other coefficients being zero, thus the specified model could represent the model specified by Stevenson (1980) and Battese and Coelli (1988). However, if all the estimated coefficients in the inefficiency model sum up to zero, Battese and Coelli (1995) states that the technical inefficiency effects will be unrelated to the specified variable and hence the specification of the by

Aigner *et al.* (1977) will be attained. Huang and Liu (1994) on their part state that if there are any form of interaction between firm-specific parameters and input parameters, which are included in the inefficiency model, the model reduces to a non-neutral stochastic frontier.

Jondrow *et al.* (1982) specified that if we are to work within the framework of the normal-half normal stochastic frontier model by Aigner *et al.* (1977), then the conditional estimator of the inefficiency term u_i is derived from the conditional distribution of u_i expressed as:

$$\hat{u}_i = E[u_i/\varepsilon_i] = \frac{\delta\lambda}{1+\lambda^2}\left[\frac{\phi(a_i)}{1-\phi(a_i)} - a_i\right] \quad 5$$

where $= \left[\delta_v{}^2 + \delta_u{}^2\right]^{\frac{1}{2}}$, $\lambda = \frac{\delta_u{}^2}{\delta\delta_v{}^2}$, $a_i = S\varepsilon_i\frac{\lambda}{\delta}$ is the standard normal density which is evaluated at a_{it} and $\emptyset(a_{it})$ refers to the standard normal cumulative density function (CDF) evaluated at a_{it}.

From the Jondrow *et al.* (1982) conditional estimator of the inefficiency model above, the inefficiency frontier differs from that specified by Reifschneider and Stevenson (1991) in the w-random variables in the inefficiency model which are not identically distributed nor are required to be non-negative. Battese and Coelli (1995) however, in their use of panel data for their analysis have not accounted for the unobserved heterogeneity in the model as observed by Greene (2002, 2005). Kumbhakar *et al.* (2011) however, explains that the Jondrow *et al.* (1982) estimator of inefficiency is not consistent in cross-sectional models and that a panel data will be more advantageous if inefficiency is time invariant, then we can estimate inefficiency without necessarily stating a distributional assumption. The discussion of this study follows the Battese and Coelli (1995) specification where farm-level technical inefficiency is exogenous to the specified production function.

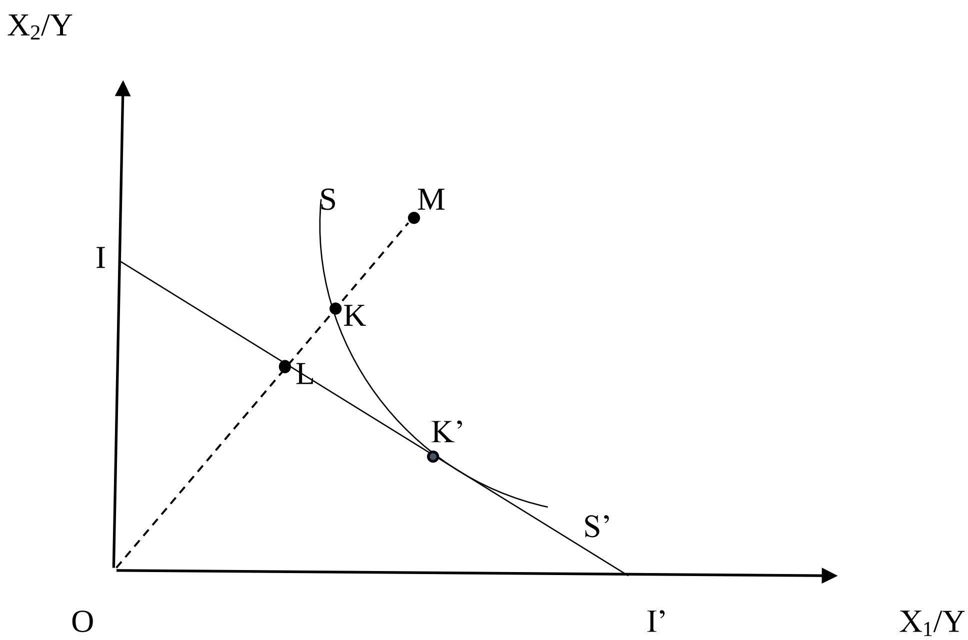
3.6 Conceptual framework of efficiency measurement

Several studies concerned with measuring production efficiency have tried to find an efficient way of constructing an optimal (frontier) production output (Berger and Humphrey, 1997). However, since inefficiencies occur often in most production processes, attempts have generally been made to find level of production that are considered as efficient output levels. According to Greene (2005), a firm's levels of efficiency is defined by how the observed output is related to the hypothesized frontier (optimal) production output. Generally, a firm's production is efficient if it produces on the production frontier but any deviations from the frontier (production lying below) output are considered as inefficient. These inefficiencies are normally classified as technical inefficiencies resulting from the production process.

The principle of technical inefficiency is based on the premise of an input and output relationships that arise from production inputs and output parameters. These technical inefficiencies come up as a result of differences that arise when the observed output given a specified amount of inputs is less than the maximum obtainable output. Since firms (production units) are generally concerned with profit maximization and cost minimization, they would choose the best input bundles that minimize the cost of inputs and maximize the output producible bundle. However, since technical inefficiencies are inherent in production, the objective of producing the efficient output is often not attained.

Thus, for a production unit to maximize profit, it must necessarily produce the highest obtainable output from a given quantity of inputs. In such a case, the firm will be considered as being technically efficient, by obtaining the optimal output with its amount of inputs. We can represent technical efficiency graphically by considering a firm that uses two inputs (x_1, x_2) to produce a single output Y. The production process is described in Figure3.3.

Figure 3.3 Measurement of Technical, Allocative and Economic efficiency



SOURCE: Coelli (1995)

Figure 3.3 illustrates the definition of efficiency by Farrell (1957) in his seminal paper. Farrell (1957) distinguished between two measures of efficiencies, namely, technical and allocative efficiencies and explained that, while technical efficiency (TE) represent the ability of a firm to obtain an optimum output with a quantity of inputs, allocative efficiency (AE) on the other side refers to a firm's ability to use input in their best combination to produce maximum outputs given their respective prices and the level of technology. The product of these two measures of efficiency is known as economic efficiency expressed as:

$$EE = TE\ x\ AE \qquad 6$$

Within the context of efficiency from figure 3.3, a firm is technically efficient if it produces at point K, which lies on the isoquant. At M, the firm is not efficient since it lies far away from K, which represents the efficiency point. The level of technical efficiency the firm is represented by the path between the observed point (M) and the most efficient point (K) at which the firm can proportionately reduce its inputs without necessarily reducing the output relative to the origin O. The technical efficiency of the firm is then represented as:

$$TE_i = \frac{OK}{OM} \qquad 7$$

Technical efficiency measures thus lie within the range of zero and one, since it shows the ratio of the difference between the efficient point K and M (inefficient point) given as:

$$1 - TE_i = 1 - \frac{OK}{OM} \qquad 8$$

A technical efficiency value of one indicates the firm is totally efficient but an efficient value of zero implies that the firm is fully inefficient. The ratio of input prices is represented in figure 3.3 by the slope of the straight-line $I - l'$ depicting the level of efficient use of inputs given their respective prices. The allocative efficiency of the firm can easily be calculated from the figure 3.3 at point M as the ratio $AE_i = \frac{OL}{OK}$, which represents the distance between the points LK. These points represent a decrease in the cost of production given that the firm is to produce at the allocative (and technical) efficient point instead of only the technical efficient but allocative inefficient point at K. Economic efficiency is thus derived from figure 3.3 as the product of the technically efficient point and the allocative points as follows:

$$EE_i = TE_i x\, AE_i \quad (9)$$

$$EE_i = \left(\frac{OK}{OM}\right)\left(\frac{OL}{OK}\right) = \left(\frac{OL}{OM}\right)$$

3.6.1 Assumptions underlying the study

In the use of the stochastic frontier model for any empirical work, basic assumptions that underlie their use must be adhered to. In this study, three of these assumptions are

1. First, we assume that onion producers in the study area are faced with identical production functions.
2. Secondly, that all farmers under study use identical production factors in their production activities and information relating to farmers' socio-economic characteristics are fully incorporated into the specified stochastic frontier model.

3. The final assumption relates to the nature of the 'composed' error term. This implies that the error terms are symmetric and distributed independently of each other.

3.6.2 Technical efficiency

The Stochastic frontier technique of estimating efficiency is used in this study. The reason for choosing the stochastic frontier is that, it makes room for sensitivity of data to random shocks through the inclusion of the conventional error term in the production from which the DEA and other methods will not do. Therefore, only deviations caused by decisions that are under the control of the production unit are attributed to inefficiency (Jaforullah and Premachandra, 2003). A production frontier function can be written as:

$$Y_i = f(x_i \, \beta) + \mathcal{E}_i \qquad Where \;\; i = 1,2,\ldots,$$

$$\mathcal{E}_i = \mathcal{V}_i - \mathcal{U}_i$$

Where Y_i denotes the level of output of the i^{th} sample production unit, $f(x_i, \; \beta)$ is an appropriate function such as Cobb-Douglas or transcendental logarithmic (translog) production functions, x_i is a vector of inputs for the i^{th} production unit and β is a vector of unknown parameter. $\mathcal{E}_i$ is an error term made up of two component: $\mathcal{V}_i$ is expected to account for the a random effect on production related to inputs that the production unit cannot control and is a non-negative error term related to the production-specific inputs, which makes it impossible for the i^{th} production unit to attain maximum efficiency in production. Thus, $\mathcal{U}_i$ measures the technical inefficiency effect that is not under the control of the production unit.

Stochastic Frontier Analysis approach specifies the technical efficiency of a production unit as a proportion of the observed output to the frontier optimal output based on the level of inputs used in the production process. Therefore, technical efficiency (TE) of the i^{th} production unit is:

$$TE_i = \exp(-\mathcal{U}_i)$$

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(x_i\,;\,\beta).exp(\mathcal{V}_i - \mathcal{U}_i)}{f(x_i;\,\beta).exp(\mathcal{V}_i)} \qquad 10$$

Y_i or $f(x_i;\,\beta).exp(\mathcal{V}_i - \mathcal{U}_i)$ is the observed output and Y_i^* or $f(x_i;\beta).exp(\mathcal{V}_i)$ the optimal output.

The value for the technical efficiency of a production unit has a range of 0 to 1. A technical efficiency value of 1 implies the firm has obtained the frontier optimal output and a value less than one implies that the production unit exhibits some sort of inefficiency in production. Technical inefficiency = $1 - TE_i$

Coelli and Battese (1996) assumed the error term $\mathcal{V}_i$ is identical, independently and normally distributed with a zero mean and a constant variance $N\,(0,\ \sigma_{\mathcal{V}}^2)$ whiles the error term $\mathcal{U}_i$ is also expected to be distributed as a truncation of the normal distribution with mean $\mathcal{U}_i$ and a variance $N\,(\mathcal{U}_i, \sigma_{\mathcal{U}}^2\,)$ in such a way that the inefficiency error term can be explained by independent factors as indicated by;

$$\mathcal{U}_i = \delta_i Z + W_i \qquad 11$$

Where, Z_i represent a $(1\,X\,M)$ vector of exogenous factors including gender, δ_i is a $(M\,X\,1)$ vector of unknown parameters to be estimated; and W_i are unobservable random variables.

3.6.2.1 Likelihood- ratio (LR) statistics

There are certain criteria that must be met by models used to ensure their empirical results are reliable. These criteria include the correct specification of the model and stating the assumption of the models. According to Gujarati (2003), the wrong specification of the functional form and incorrect assumptions can lead to wrong conclusions and recommendations. Coelli and Battese (1996) proposed the use of the single stage procedure which have two error terms compared with the ordinary least square (OLS) which has one error term to test for inefficiency and appropriateness of the frontier production function to obtain unbiased and consistent estimates. The maximum likelihood estimates provide the estimate of β and gamma (γ), where gamma (γ) explains the difference between the total output and the frontier output. The stochastic frontier model allows for the variance parameter, gamma, and the sigma squared to be estimated from the model. These are expressed as follows;

$$\sigma^2 = \sigma_V^2 + \sigma_U^2 \quad \gamma = {\sigma_U^2}/{\sigma^2} \qquad and \quad 0 < \gamma < 1 \qquad 12$$

The specification of the functional form is necessary in the use of the SFA approach. The Cobb-Douglas production functions have been used by many researchers because of its simplicity in relation to analysis and interpretation. However, its assumption of constant elasticity of substitution and constant returns to scale has been identified as a weakness of the model which could affect the results severely. Consequently, many studies used the translog functional form which is considered to be flexible in their estimation of efficiency. Thus, errors in specification are minimized since the translog function does not assumed constant elasticity of substitution, homogeneity or severability. Generally, the translog function in its logarithm terms is expressed as:

$$\ln Y_i = \ln f(x_i, \beta) + \mathcal{V}_i - \mathcal{U}_i$$

Where Y_i represent the output vector, x_i represent the input vector, β represent the unknown parameter vector, $\mathcal{V}_i$ represent the random error term supposed to be $N\ (0,\ \sigma^2)$ and $\mathcal{U}_i$represent the inefficient term independently distributed from $\mathcal{V}_i$.

The translog functional form chosen above satisfy monotonicity and convexity conditions and thus could be taken as the precise functional form or a functional form close to the unknown function form as a Taylor's serial development around an approximation point.

3.6.2.2 Empirical estimation of Technical efficiency

All farmers are assumed to be faced with the same production functions and thus have identical use of production inputs. Hence the key determinants that will account for inefficiency may result from farm practices and socio-economic factors that are unique to each farmer. The parameters in the stochastic model may not be linear and so taking natural logarithms on the output and input variables is needed to linearize the production parameters. The translog production functional form would be used for this empirical analysis if the Cobb-Douglas production functional form is found to be an inadequate representation of the sampled farm specifics after testing the hypotheses.

This will be consistent with many researchers (Donkoh *et al.*, (2013), Danso-Abbeam *et al.*, (2015) and Addison *et al.*, (2016)) who recently used the translog function in their studies in production efficiency. The translog production function following Battese and Coeli (1995) can be expressed as:

$$\ln Y = \beta_o + \sum_{j-1}^{5} \beta_j \ln X_{ji} + \sum_{j\leq}^{5} \sum_{k-1}^{5} \beta_{jk} \ln X_{ji} \ln X_{ki} + \mathcal{V}_i - \mathcal{U}_i \qquad 13$$

Where $Y, X_1, X_2, X_3, X_4, X_5$ *and* X_6 represents the output level (kilograms), size of farm (acres), seed sowed (kg), fertilizer applied (kilograms), labour use (person-days) and depreciation cost of water pumping machine (mechanisation) in GH₵ respectively. The empirical model for the technical inefficiency can also be specified as:

$$U_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + W\_i \qquad 14$$

Where

U_i = Inefficiency,

δ_i = coefficient,

Z_1 = Gender of respondent (dummy),

Z_2 = Respondent's age (years),

Z_3 = Formal schooling (years),

Z_4 = Access to credit (dummy),

Z_5 = Use of water pumping machine (dummy),

Z_6 = Experience in onions production (years),

Z_7 = Farm size (acres),

Z_8 = Access to extension service (dummy) and

W_i is the error term.

3.6.2.3 Variables selection and justification

Age of the farmer is included to evaluate its effect on the farmers level of technical efficiency. The age of a farmer represents his real age. The use of age as a variable is to be made distinct from farmers' level of experience. Since farming in the study area is mostly traditional, we expect to have a higher number of aged farmers. The expected sign of the age variable is either negative or positive.

Experience is the duration in years in which the respondent has been actively undertaking farming activities. The number of years of experience of a farmer is expected to impact positively in the production decision making. It is believed that the more experienced farmers are better informed in their production decisions regarding their activities since they are able to bring their years of experience to bear on their managerial decision making. Experience can be a substitute for managerial expertise in the production process. Experience is expected to impact positively on farmers' production behaviour and thus reduce technical inefficiency. Experience is expected to carry a negative sign in the inefficiency model.

The education variable represents the number of years of formal schooling that is achieved by the farmer. The farmers' years of formal schooling can also serve as a proxy for managerial know-how in the application of production inputs. Higher formal education of farmers' together with high levels of farming experience is expected to lead to better managerial decisions in the of inputs. Education is projected to also carry a negative sign in inefficiency model since increasing education is expected to lead to the reduction of inefficiency.

Most farmers in the rural areas depend on family members for their labour. Farmers with large family size are expected to have an advantage over those with small family size at the right time, especially during peak farming periods. Therefore, it expected that family size would have positive effect in raising the farmer's production efficiency, if actually the members are in the working force.

Farm distance is defined as the distance covered by the farmer from his house to the farm in walking kilometers. It is argued that, as farm plots are far from the house of the farmer, it would be more difficult to manage the farms timely. Based on this argument, it was expected that the farmers living nearby to their farm plots would more efficient than the one living at the farthest distant from the farms.

Farm size appears in both the specified production frontier model and the inefficiency model. The inclusion of farm size in the inefficiency model is to explain the effect of changes in the size of production on the efficiency of farmers. This inclusion is conventional and based on the assumption that farm size causes a shift in the frontier and further pushes the farmer much closer to the efficient frontier. The expected sign of farm size is negative.

Access to extension service refers to the ability of a farmer to receive technical advice from agricultural experts or extension agents either by visiting the extension agents or receiving visits by the extension agents. Access to extension service is a dummy variable with the value of zero assigned to farmers who did not receive extension service and the value of one assigned to farmers who had extension service in the cropping season under review. Access to extension service is a medium for the dissemination of new technologies among farmers and hence improves the efficiency of farmers. Farmers are able to learn more about improve practices and new ways of managing farms business which can lead to high output. Therefore, for this study, it is expected that access to extension service will have a negative effect on inefficiency.

Gender has to do with the roles and responsibilities assigned to men and women by the society. Gender is a dummy variable with a value of one assigned to male farmers and zero to female farmers. Since female farmers are less exposed to farming operations (Dossah & Mohammed, 2016); they have fewer practical experiences in farming operation and would probably use inputs less optimally than male farmers. Female farmers are responsible for many household domestic activities, they may not accomplish the farming activities on time and efficiently. Therefore, it is expected that female farmers will be less efficient compared with their male counterpart.

3.6.3 Allocative efficiency analysis

The elasticity of production measures the achievement of obtaining an optimal output from a given bundle of inputs. Elasticity of production refers to the proportionate change in output as a ratio of a percentage change in inputs used in production. (Farrell, 1957). In measuring the efficiency of the production of onion farmers', it is important to estimate the elasticities and returns to scale of the input parameters in the production function. These elasticities of the input variables are necessary in the estimation if we are to find the degree of responsiveness of output to adjustment in factor inputs used. The elasticity of production a factor input is given as:

$$e_{ij} = \frac{\partial \ln E(Y)}{\partial \ln E\left(X_{ij}\right)} = \beta_i + \sum_{i=1}^{5} \beta_{ij} lnX_{ij} \qquad 15$$

The marginal value productivity (MVP) and the marginal factor cost (MFC) were used to estimate the efficiency level of farmers in the use of their resources in the study area. This approach is by Goni *et al.* (2007), Danso-Abbeam *et al.* (2015) and Abdu *et al.* (2015). In this method, the MVPs for each input used is calculated and then equated to their corresponding purchased price (MFC). The factor elasticities estimate (β_i) and the marginal physical products (MPP) from the frontier production function according to each input used are used to compute the MVP as:

$$MVP = MPP_{xi} \,.\, P_y \qquad 16$$

Where MPP_{xi} is marginal value of the specified input variable and P_y is the per unit price of the output. MPP_{xi} is derived as:

$$\beta_i = \frac{\partial Y}{\partial X_i} \cdot \frac{X_i}{Y} = MPP_{xi} = \frac{\partial Y}{\partial X} = \beta_i \frac{Y}{X} \qquad 17$$

Where X_i represent the mean of the input variable, Y represent the output and β_i represent the

elasticity of the variable in the production function. MVP can then be specified from the above specification as:

$$MVP_{xi} = \frac{\partial Y}{\partial X_i} . P_y \qquad 18$$

The derivation of the marginal factor cost of the variable input is given as:

$$MFC = P_{xi} = MFC_{xi} = \beta_i \frac{\partial Y}{\partial X_{xi}} . P_x \qquad 19$$

3.6.4 Economic efficiency

Economic efficiency combines both the technical and allocative efficiencies. Economic efficiency refers to the best possible selection of inputs and product blend according to their price relation or the capacity of a production unit to obtain optimal profit by comparing their marginal revenue of inputs used to their corresponding marginal cost. For a production unit to be economically efficient, it must produce along the production frontier function and on the expansion path. According to Farrell (1957), a production unit that achieved both technical and allocation efficiency will be economically efficient and will have to adopt new investment streams for new development.

Achieving economic efficiency is essential for any production process. Then for a productive unit to achieve economic efficiency, both technical and allocative efficiencies must have been achieved. This therefore implies that a productive unit can obtain the optimal output from a minimum quantity of inputs but this may not be enough to attain economic efficiency. The production unit must necessarily have the best combination of inputs according to their respective prices in addition to obtaining the optimal output to achieve economic efficiency. Economic efficiency of a production unit is measured using an index that ranges from 0 to 1 and can be obtained by the multiplication of technical and allocative inefficiency indices.

$$EE = TE\ x\ AE$$

3.7 Resource use efficiency

The resource use efficiency ratio (ER) was computed by dividing the MVP with that of the MFC for each of the measurable input used. That is;

$$ER = \frac{MVP}{MFC} \qquad 20$$

Where

ER is resource-use-efficiency ratio and MFC represent the price of the measurable factor inputs at their geometric means. The decision rule for a resource being efficient as applied by Danso-Abbeam *et al.* (2015) and Abdulai *et al.* (2017) is presented as;

i. If $MVP_{xi} = MFC_{xi}$, ER= 1, resources are efficiently used by the farmer.

ii. If $MVP_{xi} < MFC_{xi}$, ER <1, resources are over-utilised by the farmer.

iii. If $MVP_{xi} > MFC_{xi}$, $ER > 1$, resources are under-utilised by the farmer

The summation of the output partial elasticity ($\sum EP$) of inputs is used in determining the return to scale of the production process. Returns to-scale is formulated based on the assumptions specified below:

If $\sum EP = 1$ suggests constant returns to scale and thus doubling the inputs will results in an 100% increase in output.

If $\sum EP < 1$ suggests decreasing returns to scale and thus increasing input by 100% will result in a less than 100% increase in output.

If $\sum EP > 1$ suggests increasing returns to scale and thus doubling inputs will result in more 100% increase in output. The analysis of the efficiency of the resource use in onion production is thus based on these assumptions on elasticity of the input parameters and their effect on outputs.

3.8 The Z Test

The productive difference between farmers who use water pumps and farmers that do not use water pumps was determined using the Z - Test. The Z - Test is expressed as:

$$Z = \frac{(\bar{U}_1 - \bar{U}_2)}{\sqrt{\frac{\alpha_1^2}{n_1} + \frac{\alpha_2^2}{n_2}}} \qquad 21$$

Where

$\overline{U_1}$ = mean productivity of farmers who use water pump

$\overline{U_2}$ = mean productivity of farmers who do not use water pump

α_1^2 = variance of farmers who use water pump

α_2^2 = variance of farmers who do not use water pump

n_1 = number of farmers who use water pump

n_2 = number of farmers who do not use water pump

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The results and discussion of the study are presented in this chapter. It begins with results and discussion of the socio-economic characteristics of onion farmers followed by determinants of onion output in the region, the results of the stochastic frontier production function and cost function, resource use efficiency and ends with the constraints farmers face in onion production.

4.2 Socio-economic characteristics

4.2.1 Gender

Majority (about 78%) of the respondents were males, which indicates that males dominate the onion production in the region (Figure 4.1).

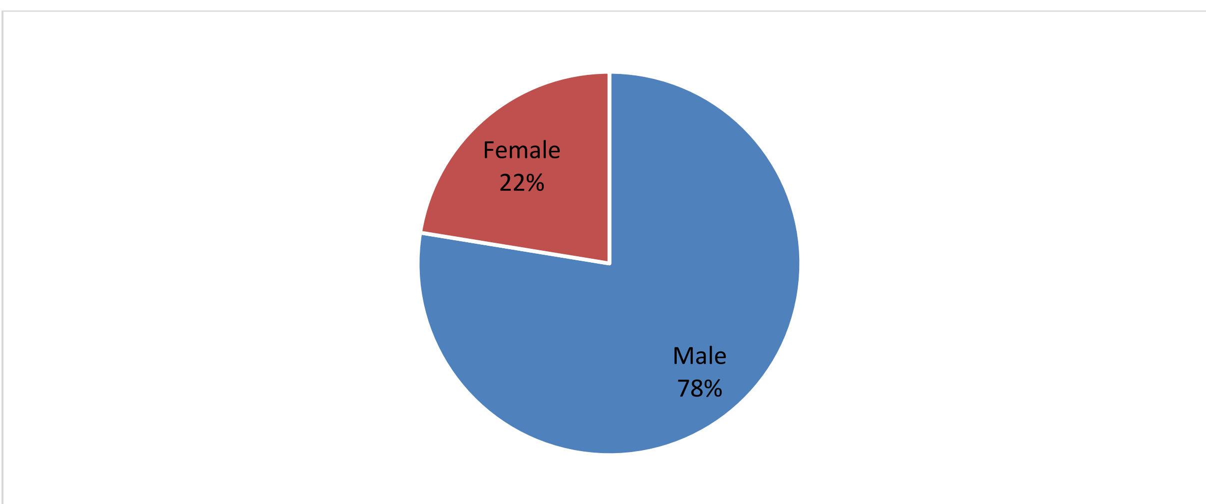


Figure 4.1: Gender of respondents

Source: Field Data, (2018).

The result is similar with the works of Yeboah *et al.* (2003), Carr (2008) and Akrofi *et al.* (2016) that a high percentage of males are involved in onion cultivation than females in the Central Region of Ghana. Although onion is a vegetable, the high percentage of male farmers' involvement in its production is consistent with the idea that when a crop has a high value and its production is seen to be profitable, men will dominate since they are seen as the producers of cash crops (Kamga *et al.*, 2016). Majority of women were however, involved in the marketing of the vegetable than men. The strenuous farming activities involved in owning and operating an onion farm among other factors could be the reason for the low percentage (22.43%) of female farmers in onion cultivation.

4.2.2 Age

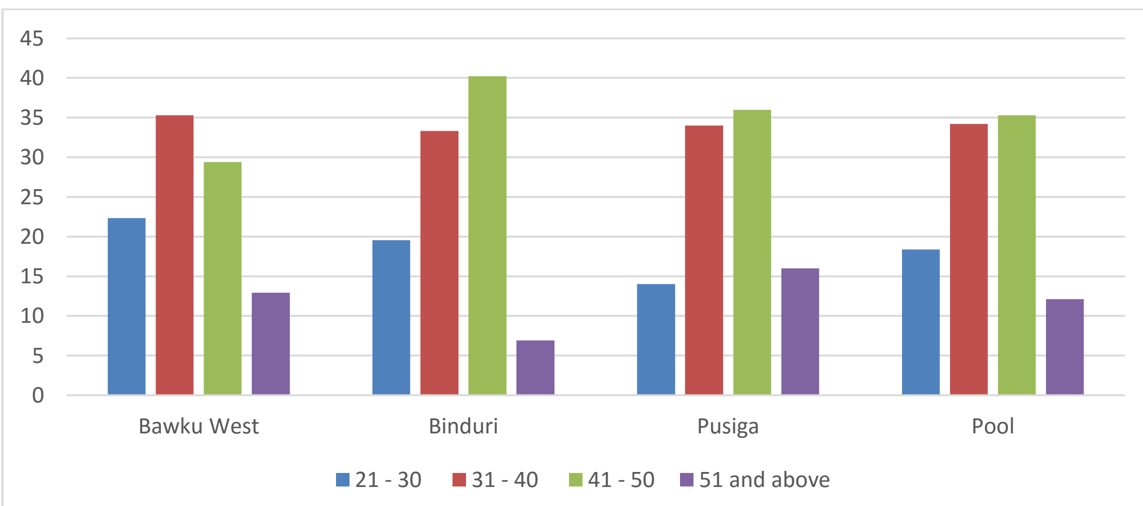


Figure 4.2: Age of respondents

Source: Field Data, (2018).

The study revealed that farmers who engaged in onion cultivation are within the age ranges of 20 years to 63 years with majority (52.57%) of them below age of 41 years and a mean of 40 years. The result, therefore indicated that most of the farmers are young energetic and are in their active age. Thus, labour productivity of onion farmers is expected to be high. The result conforms to the work of Abdulai *et al*., (2017) who had a mean age of 40.89 years. This outcome of the study is consistent with the results of Osman *et al.,* (2018) who indicated that socio-economic factor such as age have a substantial influence on the technical efficiency of farmers.

4.2.3 Education level

The results from the study further revealed that about a quarter (25.37%) of the respondents in the study area had no formal education whereas about three-quarters (74.63%) of them had at least one year of formal schooling. About 36% onion farmers had only 1 – 6 years (primary school) of formal education whiles about 18% had only 7 – 9 years (Junior High School) of formal schooling. Also, 13 % of respondent had 10 – 12 years (senior high school) of formal schooling while about 8% of farmers managed to go beyond 12 years (tertiary education) of formal schooling. The mean number of years of formal education of respondents in the study districts was 5.9 years. Education has been found to be a major factor in technology adoption in agriculture since an increase in years of formal schooling by a farmer is expected to make him prospective adopter of new technologies and best practices as well as enhance the farmer's knowledge, attitude and skill (Donkoh *et al.,* 2013). The result of the study suggests majority of onion farmers in the region did not complete junior high school or its equivalent. The result is similar to the work of Abdulai *et al.,* (2017) who had a greater percentage of small holder maize farmers in Northern Ghana having an average of 4.66 years of formal school which is equivalent to primary school education in the country. Thus, the result implies that most of the onion farmers in the study districts may not be able to read and write effectively.

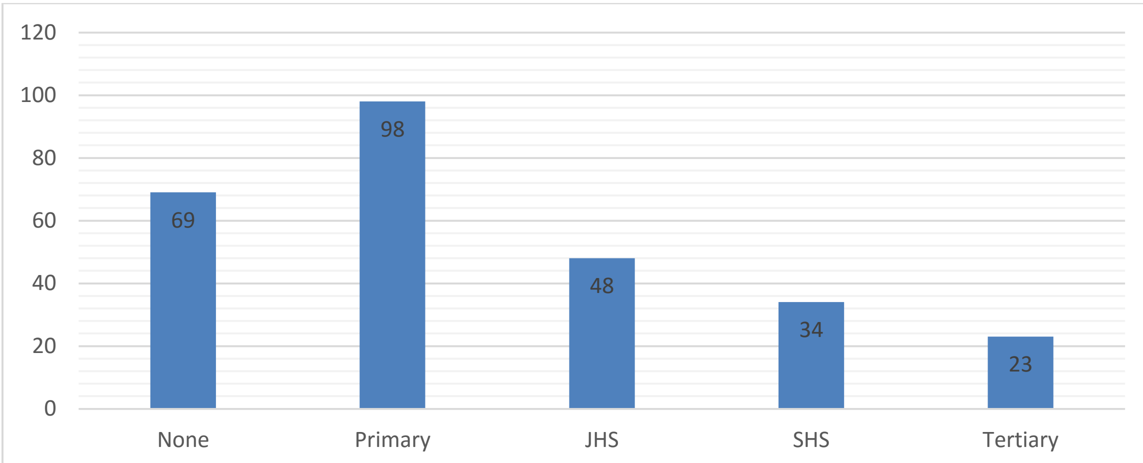


Figure 4.3: Educational levels of respondents

Source: Field Data, (2018).

4.2.4 Source of financing onion cultivation

Access to credit has been empirically proven to be an important factor that influences efficiency. Agricultural production and output could be enhanced with making credit facilities to farmers at low interest which would significantly increase the efficiency of farmers (Donkoh *et al*., 2013). Majority (85.66%) of the respondents used only their personal savings and plough back profit from the previous season to finance their farm production while 14.34% complement their finance with borrowed funds. With respect to Districts, only 5% of farmers in the Pusiga district were able to access credit, 12.64% in the Binduri District and 27.06 in the Bawku West District. Thus, majority of farmers in the study area have little or no access to credit.

The inaccessibility of access to credit by the farmers may largely be due to either the stringent measures that are usually required for obtaining the loan from the banks or to some extent ignorance to existence of the facilities. These conditions may include demand for guarantor, collateral securities, high interest rate and literacy level. Thus, the result agrees with the findings of Akudugu (2012) that high interest rate, low literacy level and group memberships are factors that hinder the demand for credit by farmers in the region.

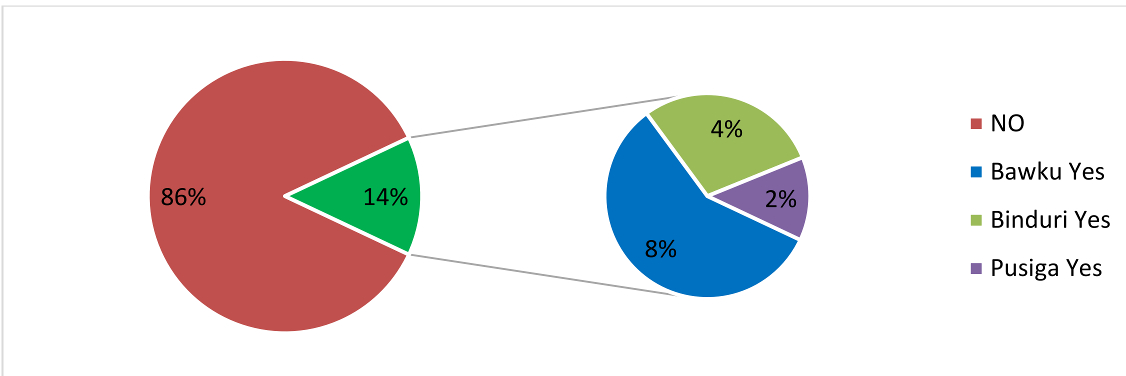


Figure 4.4: Access to credit

Source: Field Data, (2018)

4.2.5 Use of water pumping machine

Many countries have used irrigation to produce a wide range of crops and to increase their production levels. Water for irrigation is very important to onion farmers due to the cultivation of the crop in the dry season. Majority (60.29%) of the farmers use water from the rivers in the study area, 24.67% use water from dugouts with only 15.44% using dam water to irrigate their farms (Figure 4.5). This implies that most farmers must get the water from these sources to the farm manually or through the use of water pumping machines.

The use of machines in farm operations is expected to reduce strenuous farming activities associated with agriculture which in turn leads to increased production. The result from figure 4.6 revealed that over 65.44% of farmers used water pumping machines to irrigate their farms while 34.56% irrigate their farms manually.

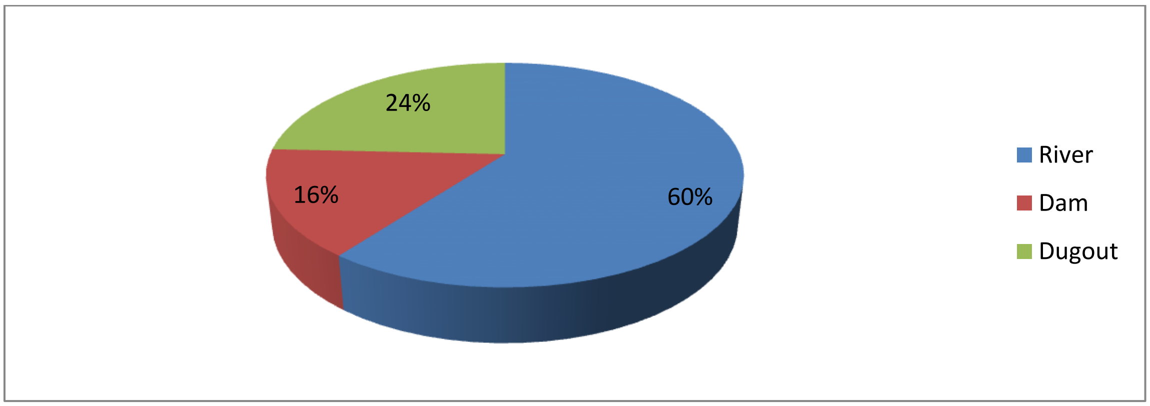


Figure 4.5: Source of water for irrigation

Source: Field Data, (2018)

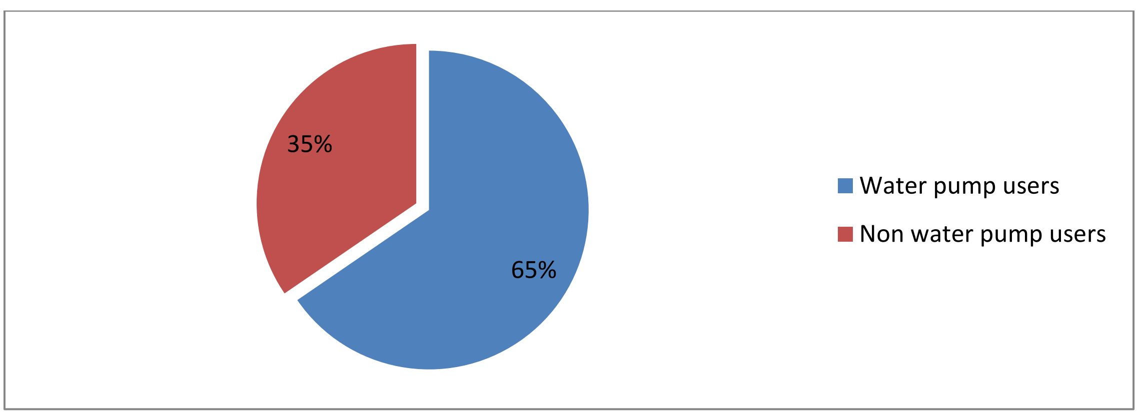


Figure 4.6: Usage of pump for irrigation

4.2.6 Experience in onion farming

Most respondents interviewed (64.34%) have been cultivating onions for over 5 years and only 36% have a period of 5 years and below experience in onion production. The average onion farming experience is 8.84 years with a maximum of 43 years of onion farming experience. This implies onion farming is not new in the study area and that farmers have acquired enough experience in onion cultivation to incorporate new innovations in farming practice which agrees with Donkoh and Awuni (2011) that farming experience enhance the willingness of farmers to change towards adopting current recommended techniques. However, some people may argue that farmers who have been in operation for long periods are conservative and are normally not willing to be innovative.

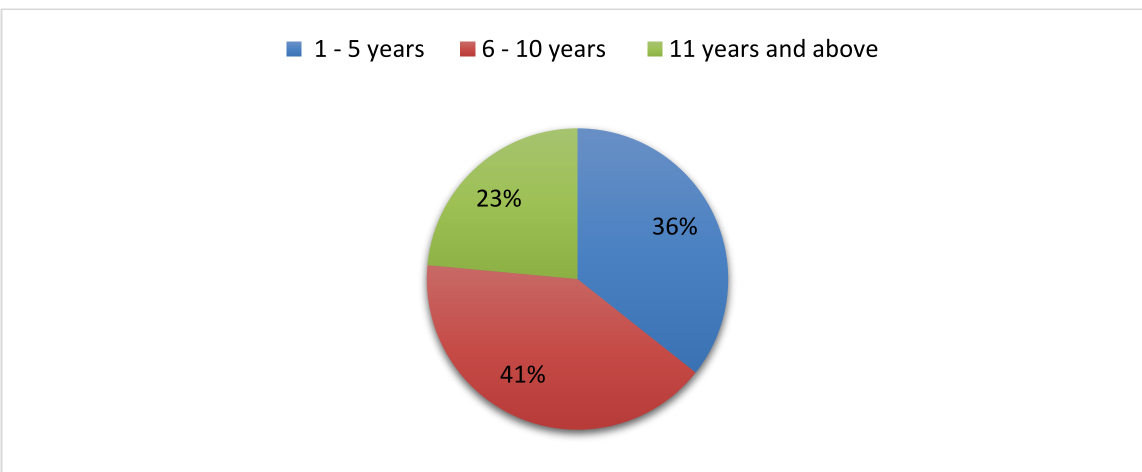


Figure 4.7: Experience of respondents

Source: Field Data, (2018)

4.2.7 Extension services

Majority (85.66%) of the respondents in the study area had access to extension services while only 14.34% of the respondents did not have extension services. On the average, respondents in the study area had contact with extension personnel about 4 times during the year. The implication is that more than half of the farmers stood the chance of being informed on new farming techniques. Extension agents employed by the government through the agricultural ministry are the main people who provide extension services to farmers in the country. Thus, the government funds the activities of the extension department of the ministry. Access to extension services as recognized in literature afford the farmers the opportunity to be better informed about production techniques as well acquire basic training and skills on how best to allocate resource to achieve higher productivity and efficiency (Haile, 2015). Therefore, if farmers have frequent contact with extension agents, they would probably learn to use productive resources more efficiently and invariably profitable in the farming venture.

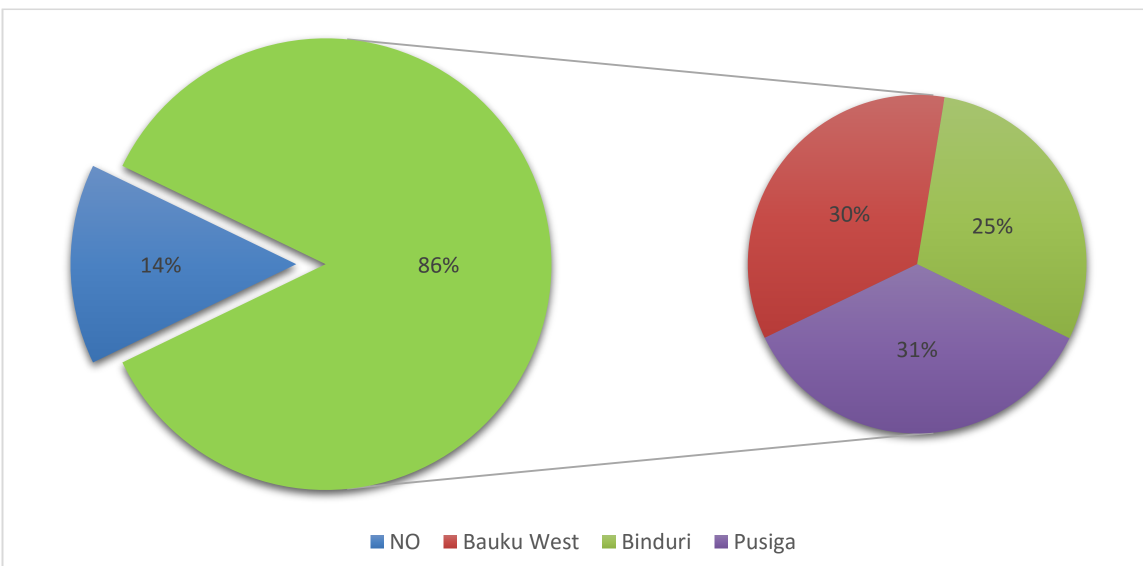


Figure 4.8: Access to extension services

Source: Field Data, (2018)

4.2.8 Household size/ source of labour

Labour is a limiting factor of production in the vast majority of West African farming systems. The mean household size of respondents in the study area is 8.44 compared with a mean of 5.9 for the region in the 2010 population and housing census conducted by the Ghana Statistical Service (GSS, 2013). The average household labour in the study area is 5.63 man-days, which indicates the presence of dependents who must be taken care of. The significance of the household size is found in the supply of labour by the members of the household. Majority of farmers in the study area rely on members of the household to provide labour for virtually all farm activities in the cultivation of onion. When family labour is not sufficient, farmers rely on group/communal labour or hired labour to complement the family labour. In this study, most farmers rely on group/communal labour to undertake farming activities that required more hands at a go although some few farmers used hired labour.

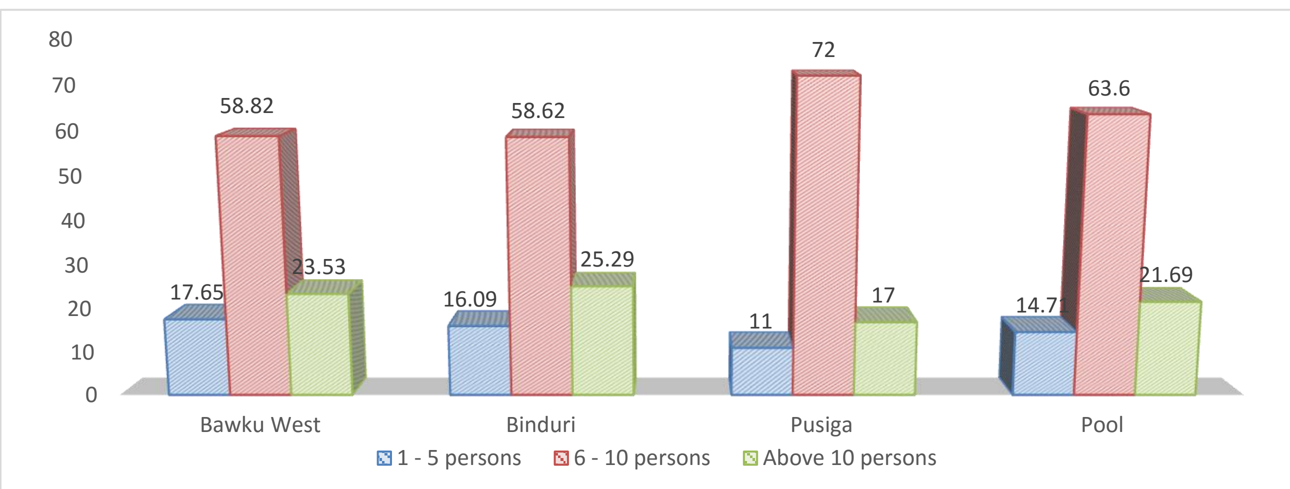


Figure 4.9 Household size

Source: Field Data, (2018)

4.2.9 Occupation

Majority (79.04%) of the respondents had farming as their main occupation with traders, salary workers artisans, among others constituting the remaining 21%. Also, about 29% of the farmers were members of FBOs, while the remaining 71% not affiliated to any FBOs although, FBOs are likely to support farmers mitigate existing and potential problems related to onion production and other relevant and vital information on farming.

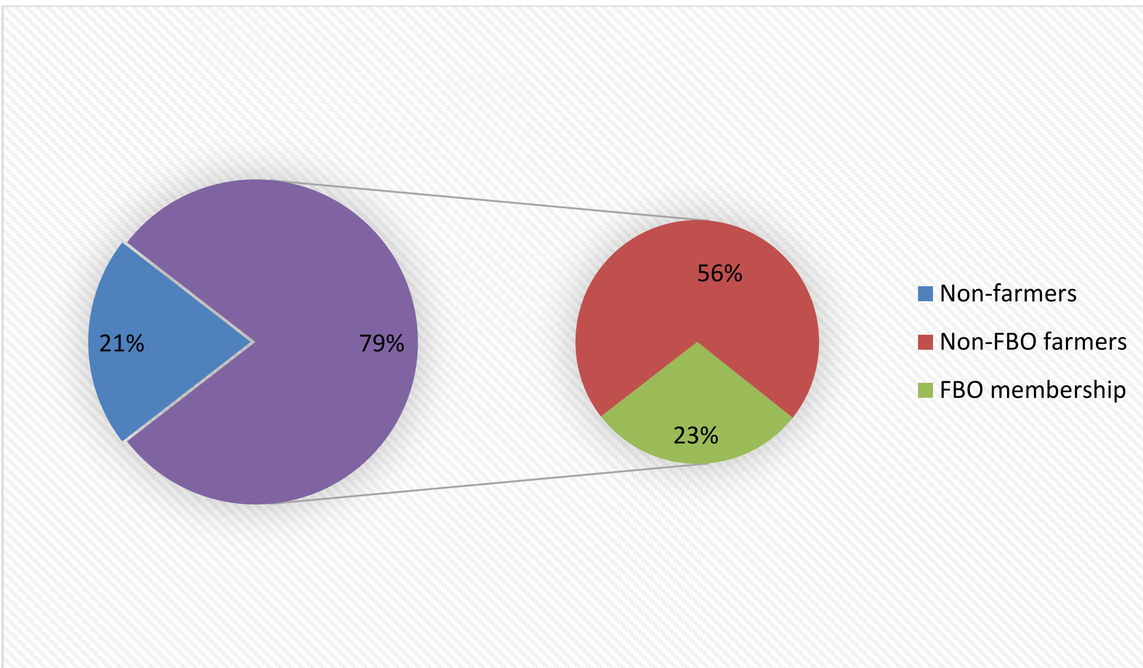


Figure 4.10: Main occupations of respondents

Source: Field Data, (2018)

4.3 Farm specific characteristics

The cultivation of onion is not possible without the availability of land making it an important productive input. There are various ways that farmers can gain access to land for farming including inheritance, share-cropping, renting, donation and

Table 4.1 Summary statistics of farm-specific characteristics

VARIABLE	Description	Mean	Std. Dev.	Min.	Max.
FARM SIZE	Number of acres of cultivated onion	1.47	0.66	0.3	3.3
ONIONSEED	Quantity of onion seed used (kg)	2.52	1.15	0.567	6.804
FERTILIZER	Quantity of chemical fertilizer (kg) used	198.63	107.88	0	500
LABOUR	Total number of days that work is done in the farm	40.13	6.34	25	62
MECHANISATION	Depreciation cost of water pumping machine (in GH₵)	113.86	119.40	0	550
OUTPUT	Quantity of Onion harvested (bags)	53.11	27.17	12	150
LAND PRICE	Rental value of land (in GH₵)	219.69	101.40	45	495
SEED PRICE	Amount paid per of seed (in GH₵)	89.77	20.47	35	100
FERTILIZER PRICE	Amount paid per kg of fertilizer (in GH₵)	1.47	0.37	0	1.7
LABOUR PRICE	Amount paid (in GH₵) for labour	11.56	8.20	0	52
ONION PRICE	Price of a bag of onion (GH₵)	140.68	28.13	26	250
SEED COST PER ACRE	Cost of seed used in cultivating onion per acre in GH₵	158.39	70.71	50	480
FERTILIZER COST PER ACRE	Cost of fertilizer used in cultivating onion per acre in GH₵	224.40	109.61	0	800
LABOUR COST PER ACRE	Cost of labour used in cultivating onion per acre in GH₵	512.12	435.08	20	3,020

Source: Field Data, (2018)

purchasing. Majority (76%) of farmers interviewed inherited the land used for onion farming which makes it more secured for continues cultivation and a bright future for the onion industry if found to be profitable. The average farm size as shown in Table 4.1 was found to be 1.47 acres of land ranging from 0.3 to 3.3 acres in the study area. Majority (76.47%) of onion farmers interviewed have a farm size below 2 acres of land which implies that they are small scale producers. This is in conformity with a study by Akrofi *et al.,* (2016) who reported that about 86% of onion farmers cultivating less than 2 acres of land in the Eastern Region. In terms of cost, land in the study area had a rental value ranging from GH₵45 to GH₵ 495 with an average of GH₵150 per acre.

Farmers used only the Bawku red seed, which is a local variety with the reason that, the imported ones do not do well due to the soil and weather conditions (GNA, 2018). Regarding the quantity of seed sowed, the results showed that 2.52kg of seed was sowed with as high as 6.80kg and as low as 0.57kg sowed. The average expenditure on a unit of seed was GH₵89.77 with a minimum of GH₵61.73 and a maximum of GH₵176.37.

In terms of agrochemical usage, the results showed that farmers applied only fertilizer and pesticides to their farm. The average quantity of fertilizer usage per acre in the study districts were as follows; 4.12 bags (50 kg) in the Binduri District, 3.6 bags in the Pusiga District and 4.24 bags in the Bawku West District. In all, a high percentage of farmers (94.49%) used fertilizer in onion farming but less than half (47.06%) of sampled farmers did not apply pesticides to their farms. The reason for the low usage of pesticides and the non-usage of weedicides could be that, majority of the respondents are low income earners coupled with their inability to access credit to use in onion cultivation find the cost of using agrochemicals very high compared using family or communal labour to manually weed their farms.

The average cost incurred by farmers on communal labour was GH¢384.93 whiles that of hired labour was GH¢956.79 during the production season. Averagely, a farmer spent an amount of GH¢722.63 on compensating labour (both communal and hired labour) ranging from GH¢30.00 to GH¢5,065.00 in undertaking all farm activities. On a person day basis an average of GH¢11.56 was spent on labour work for a day to which ranges from GH¢1.00 and GH₵51.98. Cost of water pumping machines was used as proxy for the level of mechanization. The least cost of mechanisation in the study area was GH₵50.00 and the maximum cost was GH₵550.00 with a mean cost of mechanisation of GH₵179.02 during the 2017/2018 farming season.

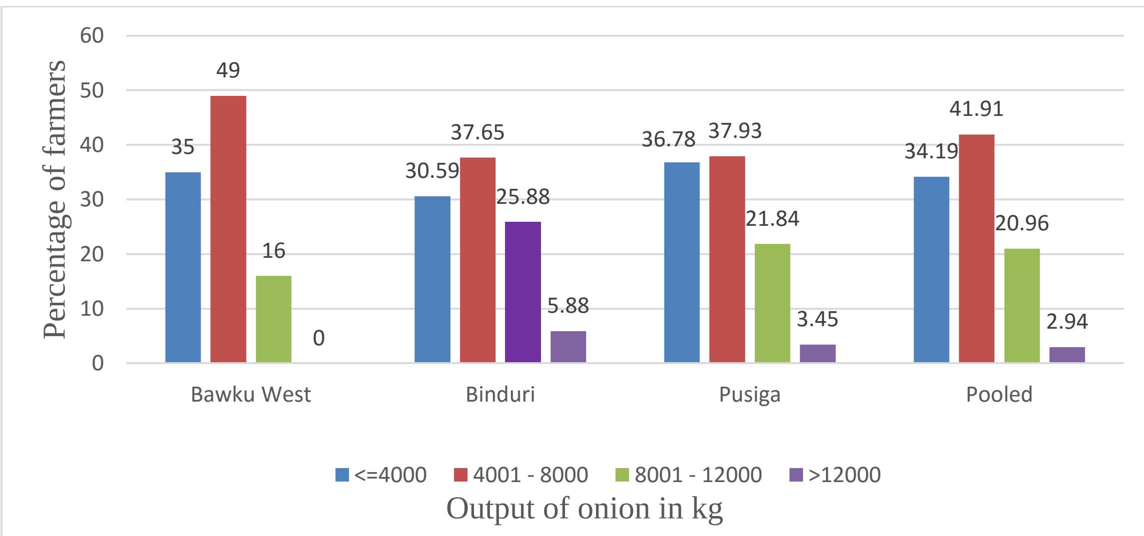


Figure 4.11: Results of onion output of farmers

Source: Field Data, (2018)

An average output of 5,842.50 kg of onion ranging from 1,320 kg to 16,552 kg was realized in the study area during 2017/2018 season of which majority of farmers (59.93%) had output less than the average output. Most respondents (76.1%) in the study area obtained 8,000 kg or less of onion whereas a minority of 2.94% farmers obtained 12,001 kg or more of onion. Also, 20.96% obtained onion output ranging from 8,001 kg to 12,000 kg (Figure 4.10).

Furthermore, 3,993.43 kg of onion was found to be the average production output per acre with a mean output of 4,475. 20 kg, 4024.18 kg and 3,557.13 kg per acre produced by farmers in Binduri, Pusiga and Bawku West Districts respectively (Figure 4.11). The results of the study show that farmers in the Binduri District are very productive compared with their counterparts in other Districts.

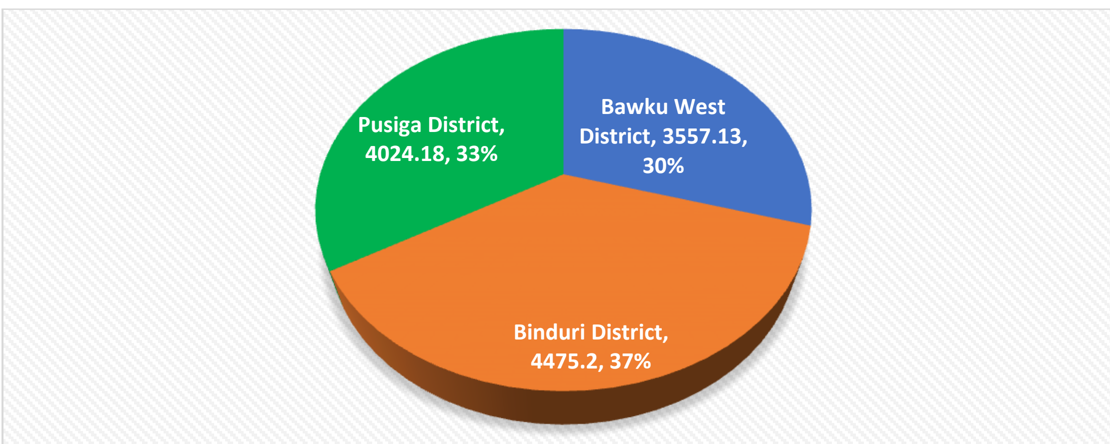


Figure 4.12: Results of onion output per acre

Source: Field Data, (2018)

4.4.1 Determinants of output

The output results from maximum likelihood estimates (MLEs) of the stochastic frontier production for onion farmers in the study area are presented in Table 4.2. The translog model was found to be appropriate at 1% level with a LR chi2(15) = 20.33 after a likelihood test was performed to test the correctness of the functional form. Therefore, the null hypothesis(H_0: $\beta_{ij} = 0$) that the Cobb-Douglas correctly represented the data was rejected.

Table 4. 2: Results of hypotheses tests

Test Type	Description	Statistics	Decision
Functional form test $(\boldsymbol{H_o : \beta_{ij} = 0})$	The Cobb-Douglas functional form is appropriate for the data	LR chi2(01) 20.33***	Reject H_o, translog is appropriate
Frontier test $(\boldsymbol{H_o : \gamma = \delta_0 \ldots \delta_8 = 0})$	Inefficiency does not exist in the model	Z value 13.85 ***	Reject H_o, Frontier is appropriate
Inefficiency test $(\boldsymbol{H_o : \gamma = 0})$	Inefficiency are stochastic	γ Value 0.846 ***	Reject H_o, Inefficiency exist in the model

Source: Field Data, (2018)

Thus, the translog model is a good fit for the data and the specified distributional assumption is accurate which is in conformity with conclusions by Danso-Abbeam *et al.* (2015). The Z value of 13.85 for gamma (γ) was also substantially different from zero at 1% and it implies that there exists considerable inefficiency and efficiency variation among onion farmers in the study area. Banani *et al*., (2013) also found inefficiency in the use of productive inputs among onion producers in Brebes Regency, East Java of Indonesia. Also, the variance ratio defined by Gamma (γ) was estimated at (0.846) which was significant at 1% probability level. The Gamma (γ) estimate explains the differences in output which arise due to technical inefficiencies of the onion farmers. Therefore, the existence of technical inefficiency among onion farmers accounted for about 85% of the variation in the output level. In other words, 85% of the variation in onion farms output was attributed to differences in technical efficiency.

All the conversional inputs used in the model had a positive influence on the output and three of them were significant at 1% with fertilizer and mechanization been significance at 5%. These conventional variables used in the model are quantity of seed, quantity of fertilizer, farm size, labour person-days and mechanisation. From Table 4.3, the most important factor determining the output of onion in the study area is farm size with a coefficient of 0.725 at 1% level of significance implying that an increase in the farm size by 100% would lead to an increase in the output of onion by 72.5%. Therefore, land can be considered as an important input in the cultivation of onion in the region. This outcome agrees with conclusion made by Anik *et al.* (2017) that an increase in the size of farm land will lead to an increase in the output of onion in their study of production and efficiency of onion cultivation in Bangladesh. Labour followed as the next most important conversional input in the cultivation of onion with a positive coefficient of 0.310 at 1% level of significance. This implies that an increase in the use of labour by 100% would lead to an increase in the output of onion by 31.0%.

The result of the study therefore conforms to that of Shemitte *et al.* (2015) that one of the important factors in agricultural production is labour. Quantity of seed used was also statistically significant at 1% level with a coefficient of 0.156. Therefore, an increase in the quantity of seed used in the cultivation of onion by 100% would lead to an increase in onion output level by 15.6%. The coefficient of quantity of fertilizer used by farmers had a positive and significant influence on the output of onion at 5% significant level in the study area indicating that the output of onion can be increased by 6.3% percent with a 100% increase in the quantity of fertilizer. The result is consistent with the outcome of Dossah and Mohammed (2016), which identify fertilizer as a very important factor in the cultivation of vegetables in the dry season.

Table 4.3: Maximum likelihood estimates of the stochastic frontier

Variable	Parameter	Production frontier		
		Coefficient	Stan. Error	Z -Value
Farm size	β_1	0.725***	0.030	25.04
Seed	β_2	0.156***	0.029	5.12
Fertilizer	β_3	0.063**	0.026	2.54
Labour	β_4	0.310***	0.076	3.75
Mechanisation	β_5	0.018**	0.007	2.56
Farm size^2	β_6	0.298***	0.053	5.30
Seed^2	β_7	0.107**	0.053	1.90
Fertilizer^2	β_8	0.010*	0.006	1.80
Labour^2	β_9	0.024	0.304	- 0.08
Mechanisation^2	β_{10}	0.022***	0.004	5.49
Farm size Seed	β_{11}	-0.255***	0.089	-2.73
Farm size Fertilizer	β_{12}	-0.014	0.019	-0.52
Farm size Labour	β_{13}	-0.145	0.217	-0.42
Farm size Mechanisation	β_{14}	-0.022	0.014	-1.67
Seed Fertilizer	β_{15}	-0.006	0.037	-0.18
Seed Labour	β_{16}	-0.176	0.199	-0.97
Seed Mechanisation	β_{17}	0.051***	0.012	3.89
Fertilizer Labour	β_{18}	0.027	0.056	0.32
Fertilizer Mechanisation	β_{19}	-0.002	0.004	-0.77
Labour Mechanisation	β_{20}	-0.060*	0.032	-1.78
Constant	β_0	3.788***	0.039	122.65
Sigma square		0.237 ***		9.88
Gamma		0.846 ***		13.87
LR chi2(01)		20.330 ***		
Wald chi2(20)		1296.170 ***		

Legend: *, ** and *** indicate the statistically level of significance at 10%, 5% and 1% respectively.

Source: Field Data, (2018)

Mechanisation was found to have a positive influence on the output of onion production with a coefficient of 0.018 at 5% level of significance. It is the only conventional input falling out of the 1% significant level and also had the least influence on onion output in the area of study. Increased in mechanisation by 100% will expansion onion output by 1.8% when all other factors are held constant (Baree, 2012; Rajendran *et al*., 2015).

The translog production model had a lot of interaction terms being statistically significant at different degrees. Some of the coefficients had positive signs while others were found to be negative. 'Farm size squared' had a coefficient of 0.298 which was statistically significant at 1%, meaning the continuous increase of farm land by 100% will at a point increase output by 29.8%. 'Seed squared' had a coefficient of 0.107 at 5% significant level suggesting that the continuously use of seed by farmers will at a point increase output by 10.7%. "Fertilizer squared" was also found to be statistically significant at 10% level with a coefficient of 0.010 implying that the continuous application of fertilizer by farmers will at a point increase output by 1.0%. The coefficient of 'mechanisation squared' was found to be 0.022 which was significant at 1% level implying that the continuous addition of water pumps into the production of onion by farmers will at a point increase output by 2.2%. The coefficient of labour squared was found to be 0.024 but it was insignificant even at 10% level of probability.

The other interactive terms show whether the conventional inputs were substitutes or complements. 'Farm size and seed' interaction had a negative coefficient and is statistically significant at 1% level, which suggests the input pair of farm size and seed were substitutes. Another pair of input interaction that also had a negative coefficient was 'labour and mechanisiation interaction. The substitutability of this input pair follows logic since machinery can replace human labour during the performance of farm operations. Six other input pairs interactive terms also had negative coefficients but they were not even significant at 10% level. These were 'farm size and fertilizer' interaction, 'farm size and labour' interaction, 'farm size and mechanisation' interaction, 'seed and fertilizer' interaction, 'seed and labour' interaction and 'fertilizer and mechanisation' interaction with coefficients of -0.014, -0.145, -0.022, -0.006, -0.176 and -0.002 respectively. 'Seed and mechanisation' interaction were found to be significant at 1% with a positive coefficient. This indicates that the input pair of seed and mechanization was complements. The findings also showed that, the interaction of the interaction of fertilizer and labour had positive coefficients but they were both insignificant even at 10% level of significance.

4.4.2 Technical efficiency of onion farmers

The study further analyzes the effects of the socio-economic characteristics of farmers on the efficiency of onion production. Ali and Chaundry (1990), Kumbhakar *et al.* (1991) and Huang and Liu (1994) have all in related studies identified farm specific characteristics that affect farmers' efficiency. The most commonly used socioeconomic characteristics that impacts on farmers efficiency includes farmers educational levels, age, household size, credit, extension contacts and level of experience. Since farmers socio-economic characteristics impact on their technical efficiencies, these derived characteristics were related to firm-specific characteristics that affect each producer. The study used farmer-specific characteristic to measure the levels of technical efficiencies.

The examination of the inefficiency parameters is very central as a foundation for guiding the formulation of agricultural policies on what need to be done to advance agricultural production and efficiency. The socio-economic characteristics used to measure the level of efficiency of onion producers include gender, age, educational level, access to credit, use of water pumping machines, farming experience and access to extension services. These socio-economic variables were chosen based on their availability in the dataset used. The inefficiency parameters as specified are those that relate to farmers specific socio-economic characteristics, which appear to have considerable roles in determining the technical efficiency of onion farmers, which were examined using sigma (δ) coefficient. A socio-economic parameter with a positive sigma (δ) coefficient suggests a negative relationship with efficiency whereas a parameter with a negative sigma (δ) coefficient indicates a positive relationship with efficiency.

From table 4.4, age of respondents had a negative coefficient and was significant at 1%, which implies that an increase in age will increase the efficiency level of farmers. Therefore, older onion farmers are expected to be more efficient compared with their young onion farmers. This outcome is consistent with studies by Baree (2012), Tanko and Obalola (2013) and Umeze (2015) who found a positive relationship between age and technical efficiency of farmers. Another socio-economic characteristic that was significant at 1% with a negative coefficient is access to credit. Thus, an improvement in farmers' access to credit will lead to a decrease in their level of inefficiency. This finding is similar to the results of Rajendran *et al.* (2015) and Abdul-Hanan & Abdul-Rahman (2017) who found that increasing farmers' access to credit significantly decreases their inefficiency levels. This finding shows the relevance of access to credit towards onion cultivation in the study area. It is generally accepted that access to credit on time and its judicious use will positively result in an improvement in the efficiency of farmers. Access to credit demonstrates the liquidity of the farmer which determines the ability of the farmer to purchase farm inputs and undertake farm operations on time.

Table 4.4: Maximum likelihood estimation results of technical inefficiency

Variable	Parameter	Coefficients	Stan. Error	Z –values
Gender	δ_1	-0.435	0.364	-1.19
Age	δ_2	-0.157***	0.039	-4.00
Education	δ_3	-0.020	0.034	-0.61
Access to credit	δ_4	-1.174***	0.436	-2.69
Use of Water pump	δ_5	-0.516	0.400	-1.29
Experience	δ_6	-0.032	0.042	-0.76
Extension	δ_8	-0.89**	0.406	-2.19
Constant	δ_0	4.236***	1.293	3.28
Minimum		0.349		
Maximum		0.997		
Mean		0.905		

Legend: *, ** and *** indicate coefficients that are significant at 10%, 5% and 1% respectively.

Source: Field Data, (2018)

The coefficient of access to extension service was also negative at 5% level of significance which meant that extension delivery is very important in reducing the inefficiency level of dry season onion cultivation in the study area. Therefore, farmers who had access to extension services were found to be more technically efficient than those who did not. This result is not surprising since farmers who get access to extension services would receive knowledge and training on best farming practices and adoption of improved technologies.

4.4.3 Distribution of technical efficiency of Onion Farmers

The technical efficiency indices obtained from the estimation of the stochastic frontier analysis in Table 4.5 shows that the least efficient farmer had a score of 0.340 (34.0%) whilst the best efficient farmer had a score of 0.995 (99.5%) with a mean efficient level of 0.904 (90.4%). Therefore, onion farmers in the study area were only able to obtained 90.4 % of the frontier output with the resources and the level of technology at their disposal. Although this result indicates a reasonable high level of technical efficiency on the average farm, there is still an opportunity for farmers to improve their efficiency level since they are producing below the optimal level. Thus the 9.6% gap in observed output level from the frontier output could be bridge with improvement in the efficiency of resource allocation without incurring further cost.

Majority of onion farmers (71.59%) had a technical efficiency score above 0.901 with the remaining 28.41% having a technical efficiency score of less than 0.901 (Table 4.5).

Table 4.5: Technical efficiency distribution of onion farmers

Distribution Range	Technical Efficiency							
	Pooled		Binduri District		Pusiga District		Bawku West District	
	Freq	*%*	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*
0.00 – 0.50	1	0.37	0	0.00	1	1.00	0	0.00
0.51– 0.60	6	2.21	0	0.00	5	5.00	1	1.18
0.61 – 0.70	11	4.04	3	3.45	5	5.00	3	3.53
0.71 – 0.80	15	5.51	4	4.60	8	8.00	3	3.53
0.81 – 0.90	44	16.18	22	25.29	12	12.00	10	11.76
0.91 – 1.00	195	71.69	58	66.67	69	69.00	68	80.00
Total	272	100	87	100	100	100	85	100
Minimum	0.340		0.626		0.340		0.513	
Maximum	0.995		0.993		0.983		0.995	
Mean	0.904		0.907		0.883		0.923	

Source: Field Data, (2018)

4.5 Cost efficiency of Onion Farmers

The stochastic frontier cost function to determine the cost efficiencies of onion farmers in the study area.

4.5.1 Cost efficiency of onion farmers

The result of the estimation of the maximum likelihood of the stochastic cost function is presented in Table 4.7. The stochastic cost frontier model generally performed well, with a Wald test statistic of 5168.90 (p-value = 0.000). The value of lambda was found to be 2.93 and significant at 1% level. Therefore, the study rejects the null hypothesis of the absence of inefficiency and thus supports the presence of inefficiency effects among onion farmers in the study area. The gamma was found to be approximately 0.896 and significant at 1% level. In other words, 10.4% of the variation is due to stochastic noise. This implies that 89.6% of difference in production cost among the sampled respondents in the region was attributed to efficiency variables in the inefficiency cost model whiles 10.4% of the variation in cost efficiency is caused by factors that the farmers have no control. The sigma squared is significantly different from zero with an estimate of 0.042 sigma square at 1% level of significance. This proves the model is a good fit for the data and the assumption of the distribution of the composite error term was correct which suggest that production in agriculture is characterised by uncertainties. The translog functional form was found to be appropriate instead of Cobb Douglas. All the conventional inputs cost estimate of the parameters carried the expected sign and were significant at 1% level of probability, indicating that the determinants of total cost of onion cultivation in the region include cost of these inputs. Thus, the use of these inputs has cost implications for the onion farmer. All other things been equal, an increase in output by 100% will result in a 13.4% increase in the cost of onion cultivation. Similarly, an increase in the price for land, seed, fertilizer, labour and mechanisation by 100% will results in an increase in the cost of production by 63.6% 14.3%, 20.3%, 35.2% and 8.9% respectively.

Four of the squared terms were significant at different levels of probability. The output price squared as well as rental value of land squared had negative coefficients at 5% and 1% respectively whereas those of square of seed price, square of fertilizer price as well as square of labour price had a positive relationship with the cost of onion

Table 4.6: Maximum likelihood estimates of the stochastic cost frontier

Variable	Parameter	Cost frontier		
		Coefficient	Stan. Error	Z - values
Output	β_1	0. 134***	0.041	3.29
Rental value of land	β_2	0. 636***	0.044	14.34
Seed price	β_3	0. 143***	0.025	5.75
Fertilizer price	β_4	0. 203***	0.020	10.25
Labour price	β_5	0. 352***	0.013	26.71
Mechanisation price	β_6	0. 089***	0.006	16.71
Output square	β_7	-0.146**	0.072	-2.03
Rental value of land square	β_8	-0.399***	0.060	-6.74
Seed price square	β_9	0.110***	0.034	3.25
Fertilizer price square	β_{10}	0.033***	0.004	7.81
Labour price square	β_{11}	0.107***	0.010	10.29
Mechanisation price square	β_{12}	-0.004	0.004	-1.19
Output*rental value of land	β_{13}	0.641***	0.123	5.20
Output*Seed price	β_{14}	0.107	0.106	1.01
Output*Fertilizer price	β_{15}	0.103**	0.046	2.22
Output*Labour price	β_{16}	0.154**	0.059	2.59
Output*Mechanisation price	β_{17}	-0.032**	0.014	-2.22
Rental value of land*Seed price	β_{18}	-0.064	0.112	-0.57
Rental value of land*Fertilizer price	β_{19}	-0.087*	0.050	-1.73
Rental value of land*Labour price	β_{20}	-0.083	0.061	-1.36
Rental value of land*Mechanisation price	β_{21}	-0.010	0.014	-0.72
Seed price*Fertilizer price	β_{22}	-0.0580	0.039	-1.46
Seed price*Labour price	β_{23}	-0.104***	0.033	-3.11
Seed price*Mechanisation price	β_{24}	-0.019**	0.009	-2.03
Fertilizer price*Labour price	β_{25}	-0.008	0.008	-1.02
Fertilizer price*Mechanisation price	β_{26}	-0.006**	0.003	-2.44
Labour price*Mechanisation price	β_{27}	-0.018***	0.005	-3.37
Constant	β_0	7.26***	0.028	258.87
Sigma square		0.024 ***	0.005	5.38
Gamma		0.683 ***	0.121	5.64
LR chi2(01)		3.78**		
Wald chi2(27)		5168.90 ***		

Legend: *, ** and *** indicate coefficients that are significant at 10%, 5% and 1% respectively. Source: Field Data, (2018) production at a 1% level of significance. Thus, the continuous usage of these factors will lead to an increase in the cost of onion cultivation. Although the squares term for mechanization price were also positive, they were not significant.

Nine of the interactive terms were found to be important at different levels of significance. Among them, only output price-rental value of land interaction, output fertilizer price interaction and output price-labour price interaction had positive coefficients (0.641; 0.103 & 0.154) at 1% and 5% significant levels respectively. The other significant interactive terms had negative coefficients as follows: output and mechanization at 5%; output and labour at 5%; rental value of land and fertilizer price at 10%; seed price and labour price at 1%; seed price and mechanisation price at 5% level; fertilizer price and mechanisation price at 5%; and labour price and mechanisation price also at 1%. Generally, results with positive signs indicate the complementarity of inputs and those with negative signs implies substitutability of inputs used in onion production as discussed earlier.

4.5.2. Determinants of cost inefficiency

The socio-economic characteristics used to estimate the cost efficiency level of onion farmers were gender, age, educational level, access to credit, use of water pump, experience of farmer and extension services. From Table 4.7, the socio-economic characteristics that had significant influence on the cost efficiency of farmers at varying levels were gender, water pump and access to extension services.

The estimated coefficient of gender was positively related to cost inefficiency at 10% significant level. This implies that male farmers were inefficient with respect to combination of inputs in terms of cost. Female farmers might be taking decisions that will minimize the cost of production than their male counterparts which might be the reason why they were efficient in terms of cost than male farmers. The coefficient of the use of water pump of the sampled farmers carried a negative sign at a 5% level of significance. Therefore, an increase in the use of water pump machines in onion cultivation tends to decrease the farmer's cost inefficiency and thus increases his allocative efficiency.

Table 4.7: Maximum likelihood estimation results of cost inefficiency

Variable	Parameter	Coefficients	Stan. Error	Z - values
Gender	δ_1	0.745*	0.430	1.73
Age	δ_2	0.007	0.030	0.02
Education	δ_3	0.034	0.038	0.89
Access to credit	δ_4	-0.908	0.692	-1.31
Use of Water pumps	δ_5	-1.028**	0.458	-2.25
Experience	δ_6	-0.054	0.036	-1.47
Extension	δ_8	-1.216**	0.569	2.39
Constant	δ_0	-0.609	1.400	-4.13
Minimum		0.550		
Maximum		0.994		
Mean		0.8983		

Legend: *, ** and *** represent coefficients that are significant at10%, 5% and 1% respectively. (Source: Field Data, 2018)

Access to extension services was also negatively related to cost inefficiency at a 1% level of significance. Thus, access to extension services help farmers to reduce their inefficiencies in the use of their productive inputs. Access to extension services enable farmers to acquire knowledge on new technologies as well as how to adopt best farming practices, farm management among others which enable them to minimize their cost of production. This puts the farmer in the better position to utilise his/her limited resource to achieve higher results and hence increase their allocative efficiencies.

4.5.3. Distribution of allocative efficiency of onion farmers

The cost efficiency distribution of onion farmers is presented in Table 4.9 with a mean cost efficiency of 0.922 ranging from a minimum of 0.424 to a maximum of 0.983. Therefore, there is a reasonably high variation of cost efficiency among onion farmers in the study area. Thus, the farmer with the minimum cost efficiency score would require a gain of 0.576 (that is, 1.0 – 0.424) to achieve cost efficient while the best cost efficient farmer would require just about 0.0017 to attain optimal cost efficiency level.

Farmers that had cost efficiency score of less than 0.91 constitute only about 20.96% while the rest of the farmers had cost efficiency scores less than 0.91 in the study area. Only farmer had an efficiency score less than 0.60. This result indicates that the respondents in the region were comparatively cost efficient in producing a given level of output though they still have a small gap to fill in the allocation of their resources in order to reduce inefficiency in terms of cost of onion production.

The cost efficiency estimates presented in Table 4.8 suggest that an average onion producer would need a cost saving of just 6.21% derived from [(1 – (0.922/0.983)) x

100] in order to achieve the optimal cost efficiency in the study area. Cost efficiency in onion cultivation could also be increased by 7.8% with the given level of production technology. Thus, there are still issues that hinder the cost efficiency of onion production in the region that have to be resolved in order to achieve full efficiency.

Table 4.8: Cost efficiency distribution of dry season onion farmers

Range	**Cost Efficiency**							
Distribution	Binduri District		Pusiga District		Bawku West District		Pooled	
	Freq	*%*	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*
0.00 –0 .50	1	1.15	0	0.00	0	0.00	1	0.37
0.51– 0.60	0	0.00	0	0.00	0	0.00	0	0.00
0.61 – 0.70	0	0.00	3	3.00	2	2.35	5	1.84
0.71 – 0.80	1	1.15	8	8.00	1	1.18	10	3.68
0.81 – 0.90	10	11.49	22	22.00	9	10.59	41	15.07
0.91 – 1.00	75	86.21	67	67	73	85.88	215	79.04
Total	87	100	100	100	85	100	272	100.00
Minimum	0.424		0.632		0.628		0.424	
Maximum	0.981		0.983		0.981		0.983	
Mean	0.933		0.904		0.932		0.922	

Source: Field Data, (2018)

This study agrees with the findings of Abdulai *et al.*, (2017) who reported a 0.878 mean cost efficiency of maize producers in the north of Ghana.

4.5.4 Economic efficiency distribution of onion farmers

The multiplication of the technical and allocative efficiency was used to compute for the economic efficiency of onion farmers in the study area. Therefore, the average economic efficiency score in the Table 4.9 arises from the product of the technical and allocative efficiency scores.

T able 4.9: Economic efficiency distribution of onion farmers

Distribution Range	Economic Efficiency							
	Binduri District		Pusiga District		Bawku West District		Pooled	
	Freq	*%*	*Freq*	*%*	*Freq*	*%*	*Freq*	*%*
0.00 – 0.50	1	1.15	4	4.00	1	1.18	6	2.21
0.51 – 0.60	2	2.30	8	8.00	3	3.52	13	4.78
0.61 – 0.70	5	5.75	9	9.00	5	5.88	19	6.99
0.71 – 0.80	11	12.64	13	13.00	4	4.71	28	10.29
0.81 – 0.90	39	44.83	45	45.00	29	34.12	113	41.54
0.91 – 1.00	29	33.33	21	21.00	43	50.59	93	34.19
Total	87	100	100	100	85	100	272	100.00
Minimum	0.404		0.329		0.461		0.328	
Maximum	0.975		0.954		0.967		0.975	
Mean	0.847		0.799		0.863		0.834	

Source: Field Data, (2018)

From the results, the minimum economic efficiency score in the study area was 0.328 whereas the maximum economic score was 0.975. It was found that 65% of onion farmers had economic efficiency less than the mean figure while about 34% had economic efficiency score in the range 0.91 – 1.00. The mean economic efficiency of 0.834 is relatively high implying that farmers were making judicious use of their productive resources in the study area. However, the difference between the most economically efficient farmer and the least efficient farmer is high, which suggests that there is misallocation of resources and the existence of a potential benefit to be tapped from the existing resources of farmers to increase output without incurring additional cost. The inference drawn suggests that, the average onion farmer in the study area can attain the maximum economic efficiency level if he/she experience an economic efficiency gain of 0.166 (1 – 0.834). Hence, an increase in the overall economic efficiency in the study area by 16.6% could be achieved through a reduction in the production cost. An economic efficiency again of 0.672 (1.00 – 0.328) is needed by the least economic efficient farmer to attain the maximum efficiency level while it will take just about 0.025 for the best economically efficient farmers to attain maximum economic efficiency level. This implies that there is still a gap that needs to be filled by farmers to become economically efficient in the study area.

In terms of technical efficiency, Bawku West District had highest average technical efficiency score of 92.3%, Binduri District had 90.7% and Pusiga District had 88.3%. However, the most efficient district in the area of cost efficiency was Binduri District with an average of 93.3% while least cost-efficient district happens to be Pusiga West District with 90.4%, which also had the most technical efficiency among the districts. This implies that, farmers in the Pusiga District were not using inputs efficiently as compared with their counterparts in the study area. The economic efficiency results were very close but the highest mean economic efficiency level (86.3%) was found in Bawku West District where as the least (79.9%) was found in Pusiga District. From Figure 4.3, it can be concluded that farmers in the districts were relatively efficient but serious attention is needed in other areas in order to improve the EE of onion farmers.

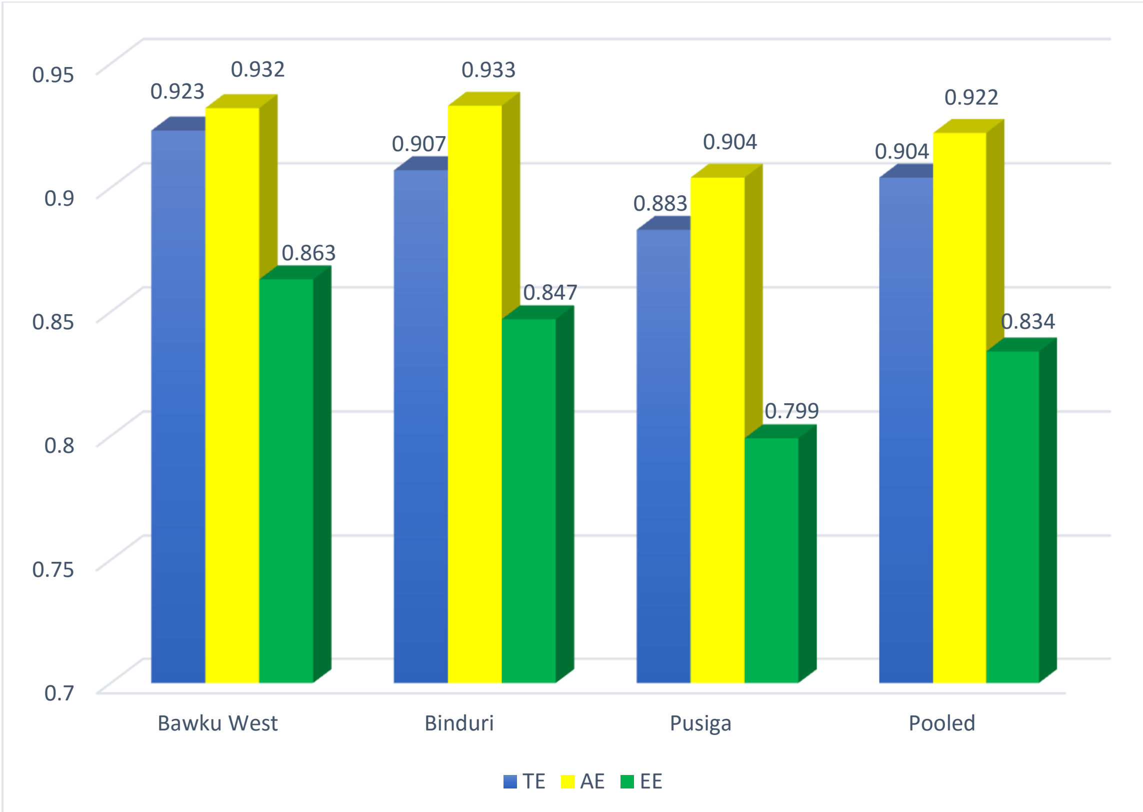


Figure 4.13: Efficiency level

Source: Field Data, (2018)

4.6: Efficiencies levels for water pump users and non-water pump users

The estimated efficiency levels for water pump users and non-water pump users are presented in Table 4.10. Farmers who use water pumps in their farms had an average technical efficiency of 0.915 whereas the average of the non-water pump user had a technical efficiency of 0.881. Furthermore, the water pump users had an average allocative efficiency score of 0.935, which exceeded the average technical efficiency score of non-water pump users of 0.897. Then again, about 79.7% of water pump

Table 4.10: Efficiencies distribution between pump users and non-pump users

Range	Technical efficiency				Allocative efficiency				Economic efficiency			
	Pump users		Nom-pump users		Pump users		Nom-pump users		Pump users		Nom-pump users	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0.0 – 0.50	1	0.6	0	0.0	0	0.0	1	1.1	4	2.3	2	2.1
0.51 – 0.60	5	2.8	1	1.1	0	0.0	0	0.0	4	2.3	9	9.6
0.61 – 0.70	5	2.8	6	6.4	1	0.6	4	4.2	7	3.9	12	12.8
0.71 – 0.80	6	3.5	9	9.5	2	1.3	8	8.5	14	7.8	14	14.9
0.81 – 0.90	19	10.6	25	26.6	26	14.8	15	16.0	80	44.9	33	35.1
0.91 – 1.00	142	79.7	53	56.4	149	83.3	66	70.2	69	38.8	24	25.5
Total	178	100	94	100	178	100	94	100	178	100	94	100

Source: Field Data, (2018)

users scored a technical efficiency mark above 0.90 whereas 56.4% of the non-water pump users were able to obtained a technical efficiency score above 0.90.

There is a significant difference in the mean efficiencies between water pump users and non-water pump users from the results of the hypothesis testing. The mean differences in the technical efficiency, allocative efficiency and the economic efficiency between water users and non-water pump users are all significant at 1%. Therefore, the null hypotheses of no significant differences in the efficiencies levels between water pump users and non-water pump users were rejected. Thus, the water pump users were efficient than non-water pump user onion farmers.

Table 4.11: Hypothesis testing

Null hypothesis	Test statistics	Decision rule
There is no significant difference in the level of technical efficiency between water pump users and non-water pump users $H_0 = TE_{wp} - TE_{nwp} = 0$	Z – statistics 88.43***	Reject H_0 There are significant differences at 5%
There is no significant difference in the level of allocative efficiency between water pump users and non-water pump users $H_0 = AE_{wp} - AE_{nwp} = 0$	Z – statistics 35.92 ***	There are significant differences at 1%
There is no significant difference in the level of economic efficiency between water pump users and non-water pump users $H_0 = EE_{wp} - EE_{nwp} = 0$	**Z – statistics 40.84 *****	**There are significant differences at 1%**

Source: Field Data, (2018)

The high efficiencies level of water pump user could be due to greater number of days used in watering of their onion farms (average of 16.46 person-days) larger farm size (averagely 1.60 acres) and high usage of fertilizer (averagely 227.95 kg) compared with the average of 12.36 person-days of watering, 1.20 acres of farm size and 143.12kg of fertilizer usage. Also, 57.44%, 41.49% 1.06% and 0% of non-water pump users were able to supply their farm with water 12 times or less 12to 16 days 16 to 20 days and beyond 20 days respectively whereas about 8.99%, 50.56% 28.09% and 12.36% water pump users did so accordingly.

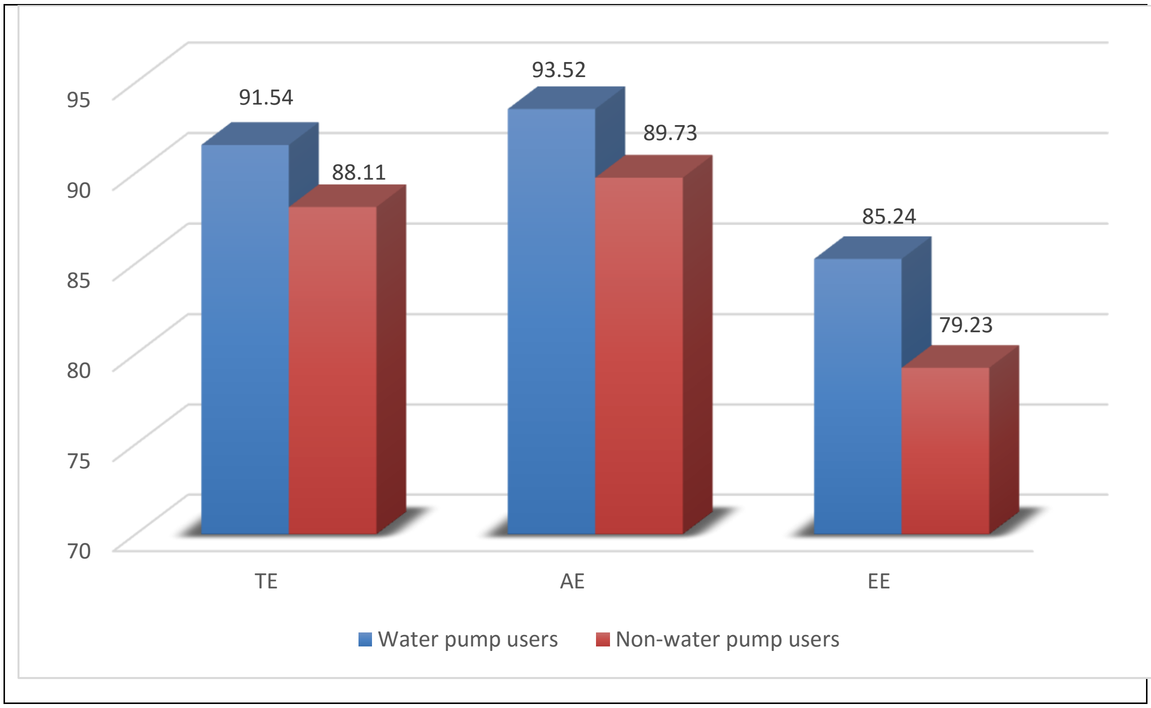


Figure 4.14 Efficiencies of water pump users verses non-water pump users

Source: Field Data, (2018)

4.7 Resource use efficiency

The resource use of onion farmers was estimated by equating the MVP to the MFC of the productive inputs. The best use of a productive resource is achieved when the difference between its MVP and MFC is not significant (i.e. MVP/MFC =1). The estimation of the optimal use of resources is based on farmers' expenditure on land, seed, labour fertilizer and mechanisation (water pumping machine) with reference to the quantities of these inputs under the given production technology. This was determined by using the elasticities from the translog estimation to compute the Marginal Physical Product (MPP) and then multiplying the MPP by the price of onion output to arrive at the MVP. The resource use efficiency (r) of the factor inputs were calculated by dividing the MVP by MFC.

Table 4.12: Elasticity and marginal physical product.

INPUT	ELASTICITY (E)	$\left(\frac{\bar{Y}}{\bar{\bar{X}}}\right)$	MPP_x	MVP=140.68*MPPx
Land	0.725	(53.11/1.47)	26.19	368.41
Seed	0.156	(53.11/4.44)	1.86	262.51
Fertilizer	0.063	(53.11/198.63)	0.02	2.81
Labour	0.310	(53.11/40.13)	0.41	57.68
Mechanisation	0.018	(53.11/113.83)	0.01	1.41

Source: Field Data, (2018)

The results of the resource-use-efficiency assessments of the various inputs are shown in Table 4.12. Farm size had a high MVP as well as resource use efficiency greater than one which suggests that land was being under-utilised in the study area since the marginal value product of land (GH¢ 368.41) is higher than the marginal factor cost of land (GH¢ 219.69). There is the need to increase the use of land by 67.7 in order for its MVP and MFC to be equal. In the same vain, the ratio of the resource use efficiency of seed was above 1 implying that seed was also being under-utilised. Thus, farmers in the study area need to increase their spending on seed by 370.95% to raise the MFC of seed (GH¢ 50.96) to match with its MVP (GH¢ 240.00) in order to achieve full utilization of the input.

Similarly, the resource use efficiency ratio of fertilizer was 1.91 which indicates that fertilizer was being under-utilised and thus requires an adjustment of about 91.16%

increase in its usage in order to achieved full utilization. Labour was also being under-utilised and will need an adjustment of 398.96% increase in its usage to make its MFC equals its MVP. In constrast to the above, Mechanisation obtained a resource use efficiency of 0.01 implying that it was being over-utilised. Thus, there is the need for onion farmers to reduce the use of mechanisation by 98.76% in order to make its MVP of GH₵1.41 equals its MFC of GH¢113.86.

Table 4.13: Resource use efficiency ratio (r) of inputs

INPUT	MVP	MFC	ER= MVP/MFC	% change required
Land	368.41	219.69	1.67	-67.70
Seed	240	50.96	4.96	-370.95
Fertilizer	2.81	1.47	1.91	-91.16
Labour	57.68	11.56	4.99	-398.96
Mechanisation	1.41	113.86	0.01	+98.76

Source: Field Data, (2018).

The summation of the elasticity coefficients of the conventional inputs was 1.34 representing an increasing return to scale of onion production in the study area. Therefore, an increase in the use of these productive inputs by 100% will result in 134% increase in the output of farmers all other things being equal. This means that onion production in the study area was still in the first stage, which buttresses the fact productive resource were being under-utilised. The increasing return to scale obtained from the study is consistent with results of Abdulai *et al.* (2017) and Osman *et al.* (2018) who obtained return to scale values 1.028 and 1.18 respectively.

4.8 Onion production constraints

Onion farmers were asked to state and rank the various categories of problems they had been facing on onion cultivation. Their responses concerning various problems in onion cultivation were collated and analysed. Farmers in the study area faced a lot of challenges to cultivate onion notwithstanding their high efficiency levels and the enormous returns of onion production to farmers. High cost of agrochemicals, inadequate water for irrigation, destruction of farm by stray animals, pest and disease attacks, postharvest losses, difficulty in acquiring land near water sources and high cost of water pumping machines were some of the constraints identified by farmers in their quest to produce onion. It was revealed that about 37% of the farmers identified high cost of agrochemicals as the major constraint they face in onion cultivation which limits their ability to access them, especially fertilizer. The fertility of soil in their farms is low because of the continuous cultivation of the same land. Hence, the need to apply fertilizer to replenish the land. Inadequate water to irrigate the onion farm was identified by 36% of farmers as the second main constraint to onion cultivation in the dry season. The vegetable is usually cultivated in the dry season due to the favourable weather conditions for its cultivation around that time. As such, the water in the rivers, dams and dug outs which they depend on to irrigate their onion farms get dried up and thus limit the bulb formation which made of 90% water content. Destruction of farm by animals was ranked the third major constraint in onion cultivation. Animal owners in the study area do not practiced the intensive system of animal rearing nor tether their animals in the dry season. The animals are allowed to find food on their own with a shepherd guiding them. Since all the grass are dried up and or burned, the animals see the green onion farms as the only place they can get their food and will usually run to farms ending up destroying the onion plants. The fourth most important constrained face by farmers was identified to be pest and disease attacks. 15% recognized the effects of pest and disease attack in pre-harvest and postharvest losses by farmers. This problem is compounded by the high cost of pesticides, which limit farmers' access to them and inadequate information on disease and pest management. Farmers particularly were worried with worm infestation, which are usually rapt in the onion leaves and are only noticed when the leaves of the onion plant are destroyed. Farmers were also concern on the efficacy of the pesticides in the markets which they claimed could not effectively deal with the worm problem. Difficulty in getting land close to water bodies was ranked the least constraint to farmers in the study area. With limited irrigation dams in the study area, most farmers cultivate onion along the rivers. Therefore, land close to the source of water is preferred because it would reduce the cost incurred in acquiring pumping machine accessories like the hose from the machine to the farm land and operation cost in terms of fuel.

Table 4.14: Onion Production Constraints (N=272)

Categories	Number	Percentage	Rank
High cost of agrochemicals	101	37.13	I
Inadequate water	97	35.66	II
Destruction by animals	59	21.69	III
Pest/Disease Attack	40	14.71	IV
Difficulty in acquiring land close to water source	22	8.09	V

Source: Field Data, (2018)

Key informant interviews were also undertaken to complement the structured questionnaire information. The key informants identified postharvest losses which occur due to the perishable nature of onion, lack of information on appropriate postharvest handling practices, inadequate storage facilities and processing technologies as constraints to onion cultivation as they reduce the profitability of onion farmers. They also recognized the increasing fuel price as a setback in their quest to produce onion because the increasing fuel cost limits their ability to pump adequate water to their farms, which can cause reduction in yield.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5. Introduction

The chapter contains the summary and conclusions of the study as well as recommendations for policy analysis and directions. Areas for possible further research that will be aimed at increasing onion productions in the country are provided.

5.1 Summary of findings

The study examined the efficiencies of small-holder onion producers in the Upper East Region in the light of its enormous contribution to farmers' income and the economic development of the country. The region was chosen because it produces most of the domestic output of onion in the country. A cross section of 272 onion farmers for the 2017/2018 farming season were selected for the study using a multi-stage sampling approach. Face-to-face interviews were conducted using a semi-structured questionnaire as the main instrument for the primary data although secondary data were also obtained from MOFA departments in the sampled districts in the region.

The study uses specific farm variables and the socio-economic characteristics of onion farms in its analysis. Descriptive statistics such as mean, frequency and percentages were used to present results of the study whiles the stochastic frontier production, stochastic cost function and MVP – MFC were used for data analyses. Major possible constraints confronting the small-scale onion farmers were also identified and ranked.

The analysis of the socio-economic characteristics revealed that; majority of farmers are within the age range of 30 – 50 years with more than 5 years' experience in onion production, low access to credit by farmers, low literacy rate among farmers and low number of female onion farmers. The result further shows a high usage of motorized water pumps and a high access to extension services among onion farmers. Finally, less than one-fifth of farmers cultivated onion more than 2 acres.

The analysis of the stochastic frontier production function identified farm size, seed, fertilizer, labour and mechanisation as the determinants of onion output in the study area. The average technical efficiency level was relatively high with the most technical efficient farmer found in Bawku West District. Furthermore, age, access to credit and access to extension services were found to be variables that reduce technical inefficiency.

The results from the estimation of the stochastic frontier cost model shows that allocative efficiency level was relatively high and the rental value of land, seed cost, labour cost, fertilizer cost and mechanisation were variables that contribute to cost efficiency of farmers. Allocative efficiency of onion farmers was positively influenced by the use of water pumps and access to extension. Also, female farmers were also found to be efficient in the allocation of resources.

The mean economic efficiency score 0.834 suggests that, farmers in the study area were relatively efficient in their overall combination and usage of inputs for onion production. Pusiga District was found to be least performing district in the overall efficiency level in the study area. Also, sampled farmers who use water pumps are more efficient in all three efficiencies than those who do not use water pumps in supplying water to their onion farms. The study also found land, seed, fertilizer and labour to be under-utilised indicating the need to increase the usage of these factor inputs in the production of onion while mechanisation was found to be over-utilised meaning a reduction in the use of water pump in onion production.

The study identified high cost of agrochemicals, inadequate water for irrigation, destruction of plant by animals, pests and diseases attack and difficulties in getting farm land near water source as the major constraints of onion farmers which need to be addressed in order to sustain or improve on the efficiency level of onion production.

5.2 Conclusions

The main aim of this study, which was to assess the resource use efficiency of onion farmers in the Upper East Region, was achieved. Specifically, the study found farm size, fertilizer, seed, mechainsation and labour to be associated with high onion output in the study area at various probability levels. The study further observed that, age, acess to credit and acess to extension services were variables that increase the technical efficiency of farmers whiles use of water pumps and access to extension services were significant factors that improve allocative efficiency. Overall, onion farmers were not economically efficient since onion output was lost due to technical and allocative inefficiencies. It was further observed that using water pumps to supply water to onion increases the efficiency level of farmers. The use of land, seed, fertilizer and labour should be increased as these inputs are under-utilized whereas mechanisation should be reduced to achieve the optimal utilization of this productive input. Finally, high cost of agrochemicals was the main constraint of onion framers in the study area although there were others such as inadequate water for irrigation, destruction of plant by animals, pests and diseases attack and difficulties in getting farm land near water sources.

5.3 Recommendations for policy implementation and further studies

Based on the empirical results of this study, the following recommendation are made:

- As part of increasing the output of onions in the country, farmers should be encouraged to expand their farm size, mechanized their farms, use improved seeds and apply the right quantity of fertilizer. Government should also formulate policies that attract the youth to onion cultivation to increase the output.
- Government and other stakeholders should formulate policies geared towards easy accessibility of loans and other credit facilities by farmers, which will help them to mechanized their farms and buy other inputs in time so as to improve their efficiency levels.
- Farmers should be encouraged to acquire water pumps and mechanised their farms since the use of motorized water pumping machines improve efficiency of farmers. Government can also promote the usage of water pumping machines in onion cultivation by creating a brand for water pump machine fuel and subsidizing it just like what pertain to outboard motor for fishing.

- Farmers should be encouraged to increase their farm size in order to increase the use of seed, fertilizer and labour as these inputs were under-utilised.
- Stakeholders, especially government should partner with the producers of agro-chemicals to make them more affordable to onion farmers and also ensure that the subsidized fertilizer is made available throughout the year. More dams should be constructed and/or support given to farmers to dig their own wells or dugouts for irrigating onion farms. These would help sustain or improve onion production in the country

The following areas can be considered for further research work on onion production.

- Research work should be carried out to evaluate efficiency of onion farmers using the whole country since the current study only focused on the Upper East Region. This will help policy makers to fashioned out appropriate policies targeted at improving the output of onion in the country.
- Also, more studies to be considered on profitability of onion production.
- Further studies can explore the marketing and value chain of onion targeted at examining the risk factors that hinders the growth of the onion sector in Ghana

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PPENDIX A

UNIVERSITY FOR DEVELOPMENT STUDIES

FACULTY OF AGRIBUSINESS AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL AND RESOURSE ECONOMICS

RESEARCH QUESTIONNAIRE

RESEARCH TOPIC: RESOURCE USE EEFICIENCY OF ONION FARMERS IN THE UPPER EAST REGION OF GHANA

Name of Enumerator …………………. Date of Interview _ _/_ _ /2018

District………………………Town ……………………. Community ………………..

Good morning/afternoon/ evening.

My name is ………… I am supporting Akanlik Vitus Anyatengbey (a student) from the above university to collect information about your onion farm activities for analysis. This questionnaire is totally for academic research purpose. The answers given to the questions will remain confidential and will not be shared with anybody. Also, there is no way the answers you provided can be traced back to you. Although I will be very grateful if you agree to respond to the questions, you may decline to participate. If you decide to participate, kindly give an honest response to every question. Thanks in advance.

1. SECTION A: SOCIO-DEMOGRAPHIC

1.0 Farmer's Name ……………………………………… Code _ _ _ _

1.1 Farmer's sex. Male [ ] Female [ ]

1.2 Age _ _ _ years

1.3 What is your level of education No Education [ ] Non-formal [ ]

Basic Level Senior High/ Technical Level [ ] Tertiary Level [ ]

1.4 Marital Status: Single [ ] Married [ ] Separated [ ] Widowed [ ]

1.5 Farmer's household Size :_ _ _

1.6 Religion Christianity [ ] Islam [ ] African Tradition [ ] Others [ ]

1.7 Are you the head of the household? Yes [ ] No [ ]

1.7.1 If no, how are you related to the head of the household? Spouse [ ]

Brother/Sister [ ] Child [ ] Others [ ] Please specify ……………………………

2. SECTION B: INCOME SOURCES

2.1. Please, rank the top three sources of income for the household.

Production/sale of crops [ ] Production/sale of livestock & livestock products [ ]

Agricultural output trading [ ] Agricultural input trading [ ] Salaried employment [ ]

Casual laborer [ ] Pension [ ] Remittances (income from relatives/friends etc.) [ ]

Others [ ] Please, specify ……………………………………..

2.2 What is your main occupation? Agriculture [ ] Trading/Commerce [ ]

Artisan/Carpentry [ ] Public Service [ ] Others [ ] Please specify…………

2.3 How much do you earn on the average per month/season? GH₵...................

2.4 If your main occupation is farming, what other work do you do?

Public Service [ ] Trading/Commerce [ ] Artisan/Carpentry [ ] Others [ ] Please, specify…………………………

2.5 How much do you earn per month from the other work? GH₵..............................

2.6 Did you have access to credit during the cultivation period? Yes [ ] No [ ]

2.6.1 If yes, please fill the table below

Source of loan	Amount borrowed	Duration	Interest paid	Use of money borrowed (A)*
Friends/relatives				
Money lenders				
Banks				

Market women				
Others				

(A)* Used for:

1-buying fertilizer 2-buying pesticides 3-payment of hired labour

4-food expenses 5-health/school fees 6-funerals/dowry

7-purchase of land 8- others

2.6.2 If No, how much of your own savings have you invested in the onion cultivation this season? GH₵.........................

3. SECTION C: ONION PRODUCTION (INPUTS)

3.1 How long have you been farming? ....

3.2 Since when did you start cultivation onion? ……………………

Land

3.3.1 How much total land do you have? *Please, state in terms of acres*………………….

3.3.2 How much of this land is used for farming? *Please, state in terms of acres* ……………….

3.3.3 What is the total size of land did you used for onion cultivation this season? *Please, state in terms of acres*………………….

3.3.4 Please state the variety of onion cultivated and the size of land for each variety in the table below

Variety of Onion cultivated	*Bawku Red*	*Garmli*
Size of land used (Acres)		

3.3.5 How did you get the ownership of this land? Purchase [ ] Rented [ ]

Inheritance [ ] Donation [ ] Share Cropping [ ] Others [ ] specify………..

3.3.6 If purchased, indicate the Cost of land purchased GH₵……………………

3.3.7 If rented or share cropping, what is the size of land used and conditions attached in using the land?

Description	Size of land	Payment in Kind	Payment in Cash	*Proportion ratio
Share in				
Rent out				

Proportion ratio 1=Half; 2=One-third; 3=Quarter; 4=One-fifth 6=Others(Specify) ………………

3.3.8 Have you increased the area for onion cultivation this season as compared to last two years? Yes [ ] No [ ]

3.3.9 If yes, by how much area? *Please, state in terms of acres*………………….

3.3.10 Do you think the acquisition of land is a constraint to onion production in the area? Yes [ ] No [ ]

Labour

3.4.1 What kind of labour did you use on your farm? Family [ ] Hired labour [ ] Both [ ]

3.4.2 If family labour is used, indicate the number of people who worked permanently on the onion farm during this season ……………………..

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

3.4.4 Complete the table below if hired labour was used.

	Family Labour					Hired Labour				
Farm Operation	Number of Workers	Duration of Work in a day	Number of Man-days used	Wage rate (GH₵)	Total Cost (GH₵)	Number of Workers	Duration of Work in a day	Number of Man-days used	Wage rate (GH₵)	Total Cost (GH₵)
Land Clearing										
Bed preparation										
Nursery Work										

Planting										
Weeds control										
Manure Application										
Pesticides										
Fertilizer Application										
Watering										
Harvesting										

Seed

3.5 Complete the table below

Variety of Onion	Type of Seed used*	Quantity of Seed Used	Price per Seed (GH₵/Kg)	Total Cost (GH₵)
Bawku Red				
Garmli				
Others				

Type of Seed Used: 1= Local Seeds 2= Improved Seeds

Fertilizer/Manure, Weedicide, Pesticide and Insecticide

3.6.1 Did you use any inputs (fertilizers, manure, weedicides and pesticides) in onion production last season?

Yes [ ] No [ ]

3.6.2 If yes, please fill out this table

Description	Quantity of used	Price per Unit (GH₵)	Total Cost (GH₵)
1.Fertilizer/ Manure (Kg)			
2. Weedicides (litres)			
3. Pesticides (litres)			
4. Insecticides (litres)			

Farm Equipment (Capital inputs)

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

Type of tool	Number	Date acquired Purchase	Price (GH₵)	Life span of tool	Annual depreciation
Sprayer					
Watering Can					
Hoe					
Cutlass					

Fork					
Basket					
Jute bags					
Water					
Others a					
B					

4. SECTION D: AGRICULTURAL EXTENSION SERVICE

4.1 Is there any informal or formal social institution in your locality? Yes [ ]

No [ ]

4.2. If yes, mention the major social institution

Cooperative union [ ] Local administration [ ]

Saving and credit association [ ] Other [ ] specify..................

4.3 Do you participate in social institutions? Yes [ ] No [ ]

4.4 If yes, what is your role?

Leadership [ ] Committee [ ] Member [ ] Other [ ]

specify..................................

4.5 How many days on average do you spend per month to in your responsibility?

………..

4.6 Who will take care of the farming activities while executing your responsibility?

Family members [ ] Hired workers [ ] Other [ ]

specify..

4.7 Do you belong to any farming organisation? Yes [ ] No [ ]

4.8 If yes, name the organisation……………………..

4.9 If not member of social institution, why?

Organisation was not useful [ ] Poor management [ ]

Organisation ceased to exist [ ] Other [ ]

specify..

4.10 Since you started onion production, have you ever received any advice from the agricultural extension agent on onion production practices? Yes [ ] No [ ]

4.11 If yes, have you received any visit of agricultural extension agents during this 2017/2018 season? Yes [ ] No [ ]

4.12 If yes, how many times did:

a. You visit any extension agent to seek for advice on onion production…………………………

b. Any extension agent visited you to give advice on onion production………………………….

c. You attend any workshop/conference on onion production…………………………..……...

5. SECTION E: OUTPUT INFORMATION

5.1 Please fill out the table.

Type of onion	Number of bags harvested	Number of bags sold	Unit price Per bed	Total value of sales	Sale outlet (B)*
Bawku Red					
Garmli					
Others					

(B)* Sale outlet

Wholesalers [1] Retailers market [2] Individual Consumers [3]

Cooperatives [4] Institutions [5] Other [6] please specify

………………

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

5.3If yes, what form? Supply of……….. Inputs [ ] Cash [ ] Others [4] specify…………

5.4 Do you have enough market demand for your onion output? Yes [ ] No [ ]

5.5 If no, what are the major reasons?

a)... b)…………………………………....

c)…………………………………..

d)………………………………………

5.6 Do you believe that the current market price for onion is fair (good)? Yes [ ] No [ ]

5.7 If no, what are the major reasons?

Low price (below average) [ ] Fluctuation [ ] Others [ ] specify................................

5.8 What is the selling price one (1) bag of onion at?

Harvesting time GH₵...................... and slack period GH₵.................. 2017/18?

5.9 Did you save part of your income from onion production? Yes [ ] No [ ]

5.10. if yes, how much did you save in the production year? GH₵......................

5.11 Where do you saved?

Home [ ] Micro finance institutions [ ] Banks [ ] Other [ ]

specify……............

5.12 Is there any interest rate associated with the money you saved? Yes [ ]

No [ ]

5.13 If yes, how much is the interest rate? …………………(%)

5.14 List the problems you faced in the production of the onion in the last production season

a) …………………………………………………………………………...……

b)……………………………………………………………………………...……

c)…………………………………..………………………………………………….

d)……………………………………………………………………………………...

Thank you for your patience and responses.

Questionnaire was checked by …………………………………… Date _ _/ _ _/ 2018