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Assessment of Competitiveness of Local Rice Production and its Contribution to Food Security in the Northern Region of Ghana

Master's thesis

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Declaration

I hereby declare that this master's thesis titled "**Assessment of Competitiveness of Local Rice Production and its Contribution to Food Security in the Northern region of Ghana"** is my own work and all the sources have been duly acknowledged by means of a thorough reference.

27th April, 2017. ……………………

Prague B.Sc. Samuel, Ahado.

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Abstract

The motivation for ensuring food security in many developing economies depends primarily on enhanced agricultural productivity through efficient use of resources. This study applied the Domestic Resource Cost (DRC) ratio and the Input-Oriented Data Envelopment Analysis (DEA) methodologies to assess the competitiveness of local rice production and its contribution to food security in the Northern region of Ghana. Tobit regression was used to evaluate the variations in efficiency scores related to some socio-economic factors of rice farmers. A farm-level data size of 135, comprising of 108 rice farmers and 27 middlemen was obtained using purposive and simple random sampling techniques. Respondents were interviewed using semi-structured questionnaires and focus group discussions to elicit all needed information. Data capturing and analysis was done using the econometric software STATA 12 and MaxDEA 7 basic, while DRC ratio and frequency tables and charts were done using Microsoft Excel. Findings from the research showed that the local rice production in the study area was not competitive and hence did not have the comparative advantage compared to other global producers in rice production. The DRC ratio of 1.35 implied that domestic resources were not used efficiently. However, efficient farmers were competitive with a DRC ratio of 0.91. The non-parametric DEA indicated inefficiency in rice production with a mean pure technical efficiency of 64 percent. The Tobit model identified farmers' experience, farm size and family hands to be the main determinants of the variations in the technical efficiency of the smallholder rice farmers. The study further found that expansion of local rice production in the area is possible and market opportunities exist considering the average yield of 2.8tons/ha. The share of the marketing margin along the rice supply chain at the farm gate and local market centres with the involvement of middlemen was 11.37 percent. Prioritising provision of linkage roads in rural areas to tackle inaccessibility would improve rice marketing and enhance the expansion of rice distribution across the country to ensure food security. National policies should favour optimum allocation of productive resources by considering the drivers of competitiveness. Appropriate crop management practices for the area should be determined and provided to rice farmers efficiently to increase rice productivity.

Keywords: Competitiveness, rice production, efficiency, resource cost ratio, envelopment, Ghana.

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List of abbreviations

AAGDS	Accelerated Agricultural Growth and Development Strategy
AE	Allocative Efficiency
AFD	Agence Francaise de Development
AGRA	Alliance for Green Revolution in Africa
ANOVA	Analysis of Variance
CRI	Crops Research Institute
CRS	Constant Returns to Scale
CSIR	Council for Scientific and Industrial Research
DEA	Data Envelopment Analysis
DFID	Department for International Development
DMU	Decision Making Unit
DRC	Domestic Resource Cost
DRS	Decreasing Returns to Scale
ECOWAS	Economic Community of West African States
EDIF	Export Development and Investment Fund Levy
EPC	Effective Protection Coefficient
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
GCNET	Ghana Customs Network
GDP	Gross Domestic Product
GPRS	Ghana Poverty Reduction Strategy
GSS	Ghana Statistical Service
HEI	Higher Education Institute
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IRC	International Centre for Rice
IRRI	International Rice Research Institute - Rice
IRS	Increasing Returns to Scale
ISSER	Institute of Statistical Social and Economic Research
JHS	Junior High School
JICA	Japan International Cooperation Agency

METASIP	Medium Term Agriculture Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MS	Mean Square
MS	Microsoft
MTADP	Medium Term Agricultural Development Programme
NERICA	New Rice for Africa
NHIL	National Health Insurance Levy
NIRS	Non Increasing Returns to Scale
NPC	Nominal Protection Coefficient
NRDS	National Rice Development Strategy
OLS	Ordinary Least Squares
PHC	Population and Housing Census
PTE	Pure Technical Efficiency
RSSP	Rice Sector Support Project
RTS	Returns to Scale
SARI	Savannah Agricultural Research Institute
SE	Scale Efficiency
SHS	Senior High School
SRID	Statistics Research and Information Directorate
SSA	Sub Saharan Africa
TE	Technical Efficiency
UDP	Urea Deep Placement
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VAT	Value Added Tax
VRS	Variable Returns to Scale
WFP	World Food Programme

1. INTRODUCTION

Background

Population growth rates in Africa are the highest in the world with Sub-Saharan Africa recording an annual population growth of 2.73 percent (World bank, 2015). Majority of the poor in Sub-Saharan Africa depend on agriculture for their livelihood thus, the agricultural sector has been conceived as an engine for spurring growth, alleviating poverty and improving food security (Awotide et al., 2012). Rice is a major staple for a significant proportion of the Asian population where approximately 90 percent of the world's rice is produced (Devi and Ponnarasi, 2009). In Asia, the bedrock of food security rest it ores on irrigated rice fields which is evident in 75 percent of the total rice produced in the continent (Virk et al., 2004).

Rice (Oryza sativa) is a chief commercial crop on the African continent, which has gained enormous significance in terms of income generation, food security and trade balance. Over the past few decades, consumption and production of rice have significantly risen in the sub-region as a result of urbanisation and population growth (Adjao, 2011). This is not surprising when the International Centre for Rice (IRC), thematically named the cereal as "Rice is life" (FAO, 2006). The consistent increase in imports across international borders fortified the strategic significance of rice for food availability, accessibility and social stability within the sub-region (Adjao, 2011).

Ghana's Medium Term Agriculture Sector Investment Plan (METASIP, 2010) aims to streamline agriculture which will result in a structurally changed economy and be evident in food security, employment opportunities and poverty reduction.
Rice is an important food crop in Ghana and about (70 percent) is being consumed among urban dwellers (IFPRI, 2014). The cereal contributes about 9 percent of the food requirements in Ghana and accounts for about 15 percent of agricultural GDP (Kranjac-Berisavljevic, 2000). The period between (1999-2008) experienced a dramatic increase in per capita rice consumption from 17.5 kg to 38.0 kg and estimated to reach 63kg in 2018 (MoFA, 2009). As a result, improving domestic production has become a high necessity of the national government. As Ghana strives to achieve exponential growth in

food production, expanding rice production has become a paramount goal. The domestic sector however, is not capable enough to meet the country's rapid demand sparked by rapid population growth, urbanisation and change in consumer habits (Addison et al., 2015). The swift-growing demand for rice is craving interest in expanding Ghana's own rice production.

Expansion of the domestic rice sector is one of the key priorities of the Ghana Poverty Reduction Strategy. The policy of Ghana's Ministry of Food and Agriculture (MoFA) is to expand locally produced rice to reduce import by about 30 percent (MoFA, 2009). Further, one of the strategies to improve food security, conserve foreign exchange and ensure self-sufficiency is to increase local production and reduce dependence on import. Encouraging domestic rice production decreases dependency on imports, which lowers stress on foreign currency reserves and ensures steady and low-price sources of food for people and also create employment as well as income for rice producers (Randolph, 1995).

A number of studies have documented a decline in Asia's rice output, hence increasing outlay in the rice sub-sector could become an attractive alternative for import-reliant countries (IRRI, 2008). This is not surprising as much of IRRI's work is centred on helping to scale-up rice production to ensure food security particularly for people who are unable to acquire adequate food for their basic consumption.

2. LITERATURE REVIEW

2.1 Introduction

Chapter Two entails an overview of agriculture particularly rice crop production in Africa and Ghana as well as its importance as a food security crop on the continent. It also includes the conceptual framework underlying the concepts of competitiveness of production, rice expansion and market opportunities, marketing margin and middlemen in rice supply chain, technology and resource use and policy environment of the rice sub-sector. Further, efficiency in production, Domestic Resource Cost (DRC) ratio, concept of Data Envelopment Analysis (DEA), as well as empirical studies on DEA and DRC ratio are presented.

2.2 Rice Production in Africa

Sub-Saharan Africa (SSA) is the most deprived region in the world. The mean per capita income in 2010, was $688 relative to $1,717 of the other developing world. A few decades back, per capita GDP in the Sub-region was 0.16 percent per year. This default in excrescence over the long term has rendered the continent in a state of paucity (Chauvin et al., 2012).

Nearly all of Africa's deprived population to a large extent depends on agriculture, and enhancing agricultural growth is key to development strategies aimed at decreasing poverty and hunger in Africa (Thirtle et al., 2003).
Despite the fact that rice is typically related with the Asian continent, it is a product of strategic significance and the quickest-growing food source in Africa, where it has been farmed for centuries. Rice is the most significant staple food, consumed by more than half of the world's populace. In Africa, rice has become an important staple and forms the basis of the food of millions of people in Sub region (Hazell et al., 2008).

According to Kormawa and Akande (2004), the demand for rice in Sub-Saharan Africa is expanding at a high pace compared to any other grain with both the wealthy and underprivileged depending on it as a main source of their nutrition. In addition, imported rice accounts for almost 40 percent of the total rice consumed in Sub-Saharan Africa, absorbing as much as one-third of the rice traded in the world rice market (Seck et al., 2010). In West Africa, about 20 million farmers are into rice production, over 100 million people depend on it directly for their living, and its role in terms of total calorie consumption was 12.3 percent (Nwanze et al., 2006).

2.3 Rice Production in Ghana

The backbone of the agrarian economy like Ghana among most developing countries is mainly agriculture and its accounts for 22.7 percent of Gross Domestic Product (GDP) with a projected annual growth rate of 4.3 percent (MoFA, 2013). Over the last decade, the local rice production in the country has increased by 7 percent annually, from 242,000 tons in 2004 to 604, 000 tons in 2014, majority of this increase emanate from area expansion (5 percent) with a paltry (2 percent) originating from productivity improvement (Ragasa et al., 2016).

Rice is strategically an important food crop and is ranked the second major consumed staple next to maize in Ghana and occupies 11 percent of total land area under cereal production and about 5 percent of the total arable land area (Martey et al., 2013). Currently, the mean yield of rice in Ghana stands at 2.6Mt/ha, which is far below the achievable yield of 4.0-8.0 Mt/ha in the trial fields (MoFA, 2013). This implies that on the average, rice farms in Ghana operate further below their productive capacity. Nonetheless, with the present technology and resources at the disposal of the country, opportunities exist for rice farm holds to tighten the existing yield gap and hence improve productivity. This can be achieved through efficient use of production resources (Asravor et al., 2015). The Northern Ghana alone account for over 64 percent of rice produced in the country (Ragasa et al., 2013).

In spite of rice been an important food security crop in the Ghanaian economy, the sector is bedevilled by constraints which hampers productivity and the incomes rural farm holds. In the northern part of Ghana, rice production is hindered by poor soil

conditions which results into poor yields, this is due to the fact that most small-scale farmers cannot afford fertilisers and other chemicals (Rhodes, 1995).
Additionally, in Ghana gender discrepancies affect crop production. Even though women are involved in rice production, there are instances where they are discriminated when it comes to access to credit facilities with the reason been that women are credit unworthy compared to their male counterparts. In areas where rice production is the predominant source of livelihood, lack of credit denies women's access to improved livelihood (MoFA, 2009).

More importantly, land holdings are a big threat and challenge to rice cultivation in Ghana considering its accessibility and safety. Even though there exist vast stretch of land in the country, holdings and outlays towards land improvement are restricted by tenure system in the country (MoFA, 2009).

Last but not least, agriculture in Ghana is constrained financially with most small-scale farmers requiring capital to shelter their investment needs. Credit facilities are not usually available and even when they are, the terms and conditions are exorbitant. Most of these smallholder farmers lack access to formal financial services due to unavailability of collaterals required by banks and other financial sectors (Namara et al., 2011).

2.4 Concept of Food Security

According to Esonu (2009), food security means possessing physical and financial access to food that is sufficient in terms of quality, quantity and safety. Food security is built on three main stakes; That is, food availability which implies that enough amount of food is obtainable on a regular basis. Food accessibility- having enough means to obtain proper foods for a healthy diet. Food utility- Proper use centred on knowledge of primary nourishment and care, as well as sufficient water and hygiene (World Food Summit, 1996). Food security is not just providing people with adequate calories to live on but safeguarding that people have abundance nutrients for optimum health.
It has been estimated that, about 805 million people globally, were chronically undernourished between 2012 and 2014, with most of the victims being women and

children (FAO, IFAD, WFP, 2014). According to Yuba (2007), nearly about 15 percent of the world populace consume more than 60 percent of the food produced and distributed, whereas the rest 85 percent live on less than 40 percent of food the world produces.

2.5 Conceptual Framework

This section explains the concepts of rice expansion and market opportunities, middlemen in the rice supply chain, production technologies in rice production and policy environment of the rice sub-sector. It also explains the concepts of both competitiveness of production and efficiency and how the two concepts help us to understand the relationship between inputs and output under a given production technology. Secondly, we delve deeper into one of the efficiency measures in which case is the Data Envelopment Analysis (DEA).

2.5.1 Rice expansion and market opportunities

Sub-Saharan Africa for sometime now has been experiencing increase in rice production. In Nigeria for example, rice production has been expanding at an annual rate of 6 percent. Increase in production emanates from acreage expansion (70 percent) with a paltry (30 percent) being productivity increase (Falusi, 1997; Fagade, 2000; AfricaRice (WARDA), 2007 and 2008).

Similarly, Ghana's rice production has seen an upsurge relative to other cereal crops and this development in the rice sub-sector is expected to continue in the no distant future. Much of the annual increase in production is allotted to acreage expansion (5 percent) compared to 2 percent originating from productivity increase (Ragasa et al., 2016). Notwithstanding the above potential of the rice sector, market opportunities exist for rice producers in Ghana as far as post harvest management practices are set in place and rice value chain development improved. This facilitates market interaction between primary producers and end market users (Addison et al., 2015).

However, Ghana's rice market is highly segregated by variety, type of processing, grain quality and source of production. This market segmentation is premium driven by influx of imported rice which expands at 40 percent per annum while local rice is shrinks at 4 percent per annum (DFID, 2015). Considering productive lowland and irrigated demonstration rice fields, there is prospects for import substitution in Ghana and in the long run, the country will be able to produce rice at volumes and various qualities the segmented domestic market demands. However, the gap between recent production and processing as well as the production structure should be bridged in order to compete with import and increasing national demand (USAID, 2012).

2.5.2 Marketing margin and middlemen in the rice supply chain

Marketing margin refers to the price movement of a commodity along its supply chain. It is used as a measure of the efficiency of the supply chain along an agricultural commodity (Abbott and Makeham, 1990). In most thriving economies in all the continent of the world, middlemen function as intermediary between producers and consumers (Oguoma et al., 2010). More often than not, agricultural supply chains are spearheaded by middlemen with enormous market authority. Usually, a cram is created between the price offered to producers and that paid by final consumers due to the exorbitant margins which distort the market (Mitchell, 2011).

Additionally, these intermediaries as a result of their high profit margin, dictate the prices of food items especially in the urban settings where there are numerous well to do who can easily afford the prices (Oguoma et al., 2010). These intermediaries derive their market control by sourcing information about market conditions along the supply chain. This means that if farmers acquaint themselves with better market information there is the likelihood of receiving higher prices as per that received from middlemen hence increasing their incomes and improving their production decisions (Mitchell, 2011). A similar study conducted by Jakob and Yanagizawa (2008) in Uganda revealed that farmers could have 15 percent higher farm gate prices through regular market information accessed by means of a radio. In most development literature, middlemen are seen to perform the role of price informant, distributor or bulk assembler.

Middlemen as bulk assemblers in the supply chain narrow the gap between farmers' farms and the point of sale (Chau et al., 2016).

2.5.3 Technology and resource use in rice production

The efficiency of resource use, technology and/or management practices are important in agricultural production. Resources may be defined as the inputs or means being its material or non material which are expended in a production process. Technology on the other hand, may refer to as a new method, idea or technical change that brings about increase in production (Rogers, 2003). Adoption of improved agricultural technologies have been reported to have positive impact on agricultural productivity growth in developing world (Nin et al., 2003). For instance, USAID (2012) reported that the use of improved seed increases yields by 25 percent while improve production technology increases yields by 40 percent. Agricultural technology kick-started with Green Revolution in Asia through modern agricultural inputs like irrigation, mineral fertilisers, improved seeds, herbicides and pesticides amongst others. Ideally, what Africa require to increase productivity is basically, effective farming systems based on modern technology for instance chemical fertilizer, improved seeds and effective and efficient crop management practices (Borlaug, 2002).

In Sub-Saharan Africa, Nerica rice which was developed by Africa Rice Centre (AfricaRice) is noticed as input free dependent though input responsive, is one of the fundamental win-win technologies that brings meaningful improvement in farmers' fields without necessarily investing in external inputs (Lancon et al., 2013).

Furthermore, report from African Agri Council dated July 26, 2016 indicated that the use of Urea Deep Placement (UDP) has been officially accepted in Tanzania as a novel technique which boost rice production by more than 20 percent per acre. This system reduces farmers' input use for instance fertiliser and slashes nitrogen losses by as much as 40 percent. In addition, smallholder farms in Sub-Saharan Africa apart from fertiliser application, irrigation systems and high yielding cultivars of rice, practice fallow periods as a traditional technique that help improve soil productivity for farms which has been cultivated for long periods (Kaya et al., 2000).

Ghana is also being challenged constantly with closing the yield gap in rice production. Nonetheless, some crop management techniques have been rolled out by the Council for Scientific and Industrial Research (CSIR) and the Ministry of Food and Agriculture (MoFA) to increase rice productivity and hence output (Ragasa et al., 2013). The package included the use of herbicides for land preparation and weed control. With this, pre-emergence herbicides application is recommended 2-3 days after sowing, while post-emergence herbicide is applied 21-25 days after planting (Ragasa et al., 2013). This methodology does not only help conserve soil moisture and improve soil fertility but also suppress the growth of weeds. In addition, planting of improved rice seed varieties, was released with these varieties having desirable traits such as high yield, early maturity, disease resistance, aroma and parboiling qualities among others (Ragasa et al., 2013). Some of these rice varieties include NERICA (for upland ecology), GR 18 (Afife), Digang (Abirikukuo), Jasmine 85 (Gbewaa), Togo Marshall (Amankwatia) are lowland varieties.

In the same vein, seed priming which involves soaking rice seeds in a clean water for half or full day and drying in the open for 24-48 hours was also one of the technological packages. Crops research institute of the CSIR posited that, primed seeds could boost yield by 25 to 40 percent relative to the non-primed seeds (Ragasa et al., 2013). Bam et al., (2006) argued that rice seeds soaked in water containing potassium and phosphorus improves germination and seedling emergence.

Not only these but also, optimal plant density in reference to row planting and spacing (recommended planting density 35-45 kilogram/hectare of rice, at a spacing of 20cm x 25cm) with two plants in a hole for transplanting takes place at 21-28 days after sowing. A plant density of 45kg/hectare is recommended for dibbling or drilling and 100 kilogrammes/hectare for broadcasting (Ragasa et al., 2013).

Similarly, appropriate fertiliser use (rate and timing of application) was also included in the package with recommended application rate of 200-400 kilogrammes/hectare of compound fertiliser (such as NPK 15-15-15) for the first application and 150 kilogrammes/hectare of sulphate of ammonia or 95 kilogrammes/hectare of urea based (Ragasa et al., 2013). Finally, adoption of bunding, puddling and levelling (collectively known as sawah system) of lowland rice fields for better water control and nutrient management.

2.5.4 Policy environment of the domestic rice sub-sector

Nations and economies can improve their competitiveness, and thus fortune, through policy reforms aiming at transforming a sub-sector in order to assume broad-based economic growth and increase productivity (Adjao, 2011). In Ghana, improving productivity and competitiveness of the rice sector through agricultural mechanisation, subsidisation of farm inputs like fertiliser, herbicides, tractors and enhancing commercial agriculture has been of key interest of government policies geared towards increasing rice production (Boansi et al., 2015). In the pursuit of enhancing agricultural productivity and narrowing the gap between domestic demand and supply of high quality rice, various government interventions have been rolled out since 2001 for the grain sub-sector to encourage production so that self-reliance and food security could be achieved.

Some of the policy interventions included the Medium Term Agricultural Development Programme (MTADP) which was developed in the early 2000s and was aimed at enhancing efficiency and effectiveness of the agricultural sector (MoFA, 2009). Further, in 2002 the Ministry of Food and Agriculture (MoFA) drafted 'Food and Agriculture Sector Development Policy' (FASDEP I) with the aim of enhancing food security, reducing poverty, providing raw material base to industries so as to ensure sustainable contribution of the agricultural sector to Gross Domestic Product (GDP), foreign exchange and government revenues. It was also aim at revamping the rice sub-sector by imposing import restrictions (import duty) as high as 20 percent to discourage rice importation into the country (Brooks et al., 2007).

As if this is not enough in 2008, Ministry of Food and Agriculture developed the 'Food and Agriculture Sector Development Policy II (FASDEP II). The main objectives were to ensure food security, exigency awareness creation of five major staple food crops (namely maize, rice, cowpea, cassava and yam). And also to escalate competitiveness and increase synergy between domestic and international market as well as create employment opportunities, improve income levels and reduce poverty and also apply science and technology in food and and agricultural development. With the rice sector, special consideration was placed on development of rice value chain, yield increase of about 50 percent, imports reduction by 30 percent and increasing productivity of irrigation schemes and intensification by 25 percent and 50 percent respectively (Boansi et al., 2015).

Also from 2009 to 2014 the "Sustainable Development of Rain-fed Lowland Rice Project" of Japan International Cooperation Agency (JICA) was effected. The project introduced novel rice production technologies such as bund formation, harrowing, farrowing, drilling, plant spacing (20*30), seed selection by soaking, fertiliser application (NKP-80kg/hectare and Nitrogen Sulphate 50kg/hectare) and use of Jasmine 85 seed in the Ashanti and Northern Regions.

Similarly, a six year (2008-2014) intervention by the Rice Sector Support Project (RSSP) backed by Agence Francaise de Development (AFD) of France sought to support lowland rice production up to 6,000 hectares in the Northern Ghana and some part of Volta region (MoFA, 2011; Ragasa et al., 2013). Finally, the present policy (NRDS) sought to double rice production by the end of 2018 with 10 percent annual increases and promote quality in order to trigger domestic demand for local rice and also to build capacity of stakeholders to patronise rice products (Angelucci et al., 2013).

2.5.5 Concept of efficiency

Efficiency is the act of achieving the maximum possible with little cost. Cooper et al., (1995) see efficiency as when a firm or sector is able to improve any of its inputs or outputs without worsening some of its other inputs or outputs. Failure to achieve efficiency may result from the lack of required technology, quality of inputs, scale of production, resource allotment and managerial ability (Mayes et al., 1994). Efficiency can be scaled-up by minimising inputs while keeping output constant or by maximising output while holding inputs constant or combination of both (collectively termed as input orientation and output orientation models respectively).

Efficiency has three components that is economic, technical and allocative where the former is defined as the product of technical and allocative efficiency. Allocative efficiency (AE) in turn is the capacity to produce a given amount of output with minimum cost (Farrell's 1957). According to Abdulai and Huffman (2000), allocative efficiency has to do with the level at which farmers efficiently make decisions by using inputs such that their marginal value product equals the marginal factor cost. Meanwhile the technical efficiency (TE) is the ability of a firm or enterprise to achieve optimum output from a given set of input used.

2.5.6 Competitiveness of production

Competitiveness is used interchangeably with comparative advantage by different researchers with the latter referring to as the fiscal cost of production of a good or evaluating the monetary performance of firms or enterprises (Cockburn et al., 1998). Other school of thoughts see competitiveness to marry with technical efficiency or production efficiency (Biggs and Raturi 1997).

According to Tsakok (1990), an economy/sector is competitive or has comparative advantage in the production of a tradable commodity if its production in the country results in a lower opportunity cost, in terms of foregone production of other goods and services, than in other countries. The competitiveness of that economy/sector is due to either if It uses fewer traded inputs per unit of output, or It uses fewer domestic resources per unit of output, or its domestic resources have lower opportunity cost, and/or the value of its domestic currency is not high relative to other major currencies.

Comparative advantage in a broader context referred to as competitiveness, is measured by comparing local economic cost of production with international reference prices, and can be summarised neatly in one indicator known as the Domestic Resource Cost (DRC) coefficient. The DRC ratio is computed as the proportion of the fiscal value of "domestic resources" relative to the economic value-added (Salinger, 2001).

2.5.7 Data envelopment analysis model

The Data Envelopment Analysis (DEA) model was propounded by Cooper, Charnes and Rhodes (1978) prior to an earlier work done by (Dantzig (1951); Farrell (1957);

Boles (1966); Shephard (1970) and Afriat (1972). The data envelopment model is a mathematical programming method for measuring the efficacy and productivity of DMUs. According to Boussofiane et al., (1991) as cited in Yong-bae et al., (2010), DEA is a tool for measuring efficacy of DMUs using linear programming procedure to encase pragmatic input-output vectors as closely as possible. That is, the efficacy of each firm is measured by the distance of its input-output piece wise surface as tightly as possible.

The main objective of the DEA is to construct a piecewise frontier over the data point without any assumptions such that all the observed points lie on or below the piecewise frontier. One of the underlying reasons the DEA has been extensively used in several sectors due to its multi-tasking ability. In examining the efficiency of production, DEA aids inefficient farms to determine to which level they could improve their inputs use relative to the "best practice" enterprise or firms (Shafiq and Rehman, 2000).

DEA model involves a three-stage application process. The first stage entails description and assortment of DMUs to be investigated. Within a DEA study, all units under consideration should perform similar tasks with objectives under the same set of 'technological' and 'market' conditions. These units should use the same kind of inputs to produce the same kind of outputs. The second stage is the determination of inputs and output variables that will be used in assessing the relative efficiency of selected DMUs.

The final stage is the application of one of the DEA models and analysis of results (Golany and Roll, 1989). After selecting DMUs to be examined, there is the need to choose a DEA model to use for the analysis. This process has two significant parts; one is related to the returns to scale assumption and the other is related to the alignments of the model. The return to scale issue is relatively easy. If the production process is observed to have constant return to scale then a relevant model would be appropriate, otherwise a variable return to scale model should be selected. Deciding the orientation of the model depends on the purpose of the analysis. Most often than not decision making processes are tailored into either administrative or policy. An input minimisation model addresses the administrative aspect of the problem on hand by addressing the question "how much input (cost) reduction is possible to produce the same level of output. This information gives decision makers an opportunity to reallocate excess inputs to more needed areas.

However, there is also a policy aspect of the efficiency assessment of institutions. Since many inputs used by DMUs are fixed or quasi-fixed, it is very difficult to reduce them in the short-run. Moreover, particularly in public policy related studies, these inputs are largely financed by taxpayers' money and involve equity and equality issues (Dinc, 2015).

2.5.8 Returns to scale in data envelopment analysis

There are subdivisions of DEA models relative to returns to scale, that is, we have the Variable Returns to Scale (VRS), Constant Returns to Scale (CRS), Non-increasing Returns to Scale (NIRS) and Decreasing Returns to Scale (DRS) by apportioning weight constraints. Prior to these however, Charnes et al., (1978) originally used the constant returns to scale approach to measure efficiency under the assumption that all the DMUs were operating at their optimum level. Subsequently, Banker et al., (1984) employed the VRS to measure efficiency thereby splitting efficiency into overall technical efficiency (TE_{CRS}) and scale efficiencies in DEA. The aforementioned returns to scales that is CRS, VRS, and NIRS frontiers are shown for five firms (A, B, C, D, and E) in Figure 2.2. From this figure, only firm C would be efficient when operating under the CRS; firms A, C, and E would be considered efficient when operating under variable returns to scale. In a situation where the NIRS and the VRS are equal, firms that lie along an efficient frontier (such as E) shows decreasing returns to scale assumption. However, when increasing returns to scale is assumed, firm B's frontier becomes unequal. In addition, when the sum of reference weights of inefficient firms is unequal to unity, it implies increasing returns assumption is applied, for the constant returns to scale frontier or the decreasing returns to scale otherwise.

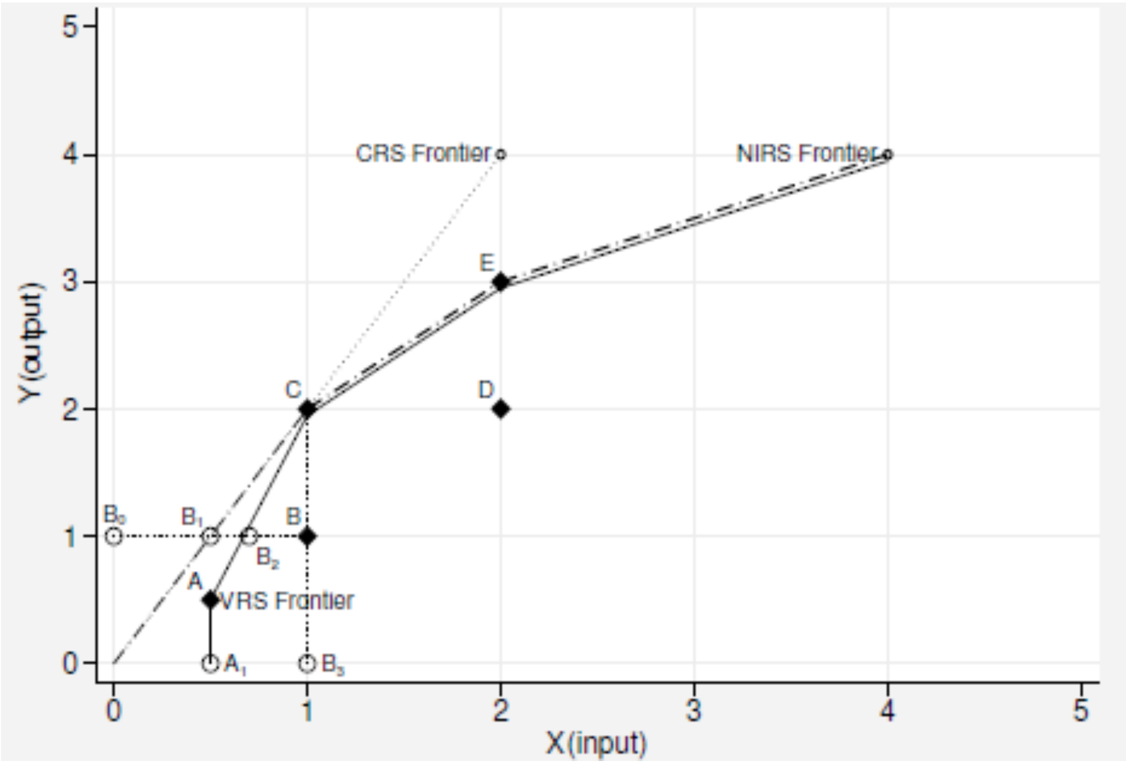

Figure 1: Efficiency and Returns to Scale (Source: Yong-bae and Choonjoo, 2010).

Under the assumption of input oriented CRS, the efficiency of firm B (denoted as θB, input, CRS) is given by = $\overline{B_0B_1}/\overline{B_0B}$. This implies that the same level of output could be achieved by reducing the amount of input use by the ratio of $1 - \theta B$, input, CRS. Similarly, under the assumption of the variable returns to scale frontier, the input-orientation is given as θB, input, VRS = $\overline{B_0B_2}/\overline{B_0B}$. However, the efficiency measure of firm C still remains the same) irrespective of the orientation since all the piecewise surfaces meet at point C. The optimum scale inefficiency can further be divided into scale efficiency and "pure" technical efficiency. The technical efficiency of point B under the variable returns to scale model encases $B2B$ and $B1B$ contributes to the technical efficacy of point B regarding the optimum scale of production (figure 2.1). Then the resultant scale efficiency is denoted by $B1B2$. The concept of efficiency, slacks, and peers are explained using a two input and one output scenario. A firm is efficient if it has a DEA score of one (1) and all slacks are zero (0) (Cooper et al., 2006).

2.5.9 The input-oriented data envelopment model

The input-oriented model has been extensively used in many studies. In the study of Coelli et al., (2005) the authors recognize technical inefficiency as a proportionate reduction of input use with output levels held constant using the input-oriented DEA. This is also in line with Farrell's input-based estimation of technical inefficiency. Essentially, the input-oriented model is preferable because the input quantities are usually the primary decision variables of the firms or enterprises and are also under the control of firm managers (Coelli et al., 2005). Conversely, Mansor et al., (2013) and Wouterse (2008) have also used the output-oriented DEA model. Coelli and Perelman (1996) however, debated that the choice of orientation has negligible effect on the scores obtained and that both orientations thus the output-oriented and input-oriented models estimate exactly the same frontier and also recognise the same set of firms as being efficient.

2.6 The Tobit model

The Tobit model was propounded by James Tobin (1958) to depict a non-negative endogenous variable, y_i and an exogenous variable (vector) xi. The Tobit model is also referred to as the censored model because some observations on the endogenous variable y_i^* (those for which $y_i^* > 0$) are suppressed. With a censored model, all the information is contained in the data set, but we do not know the "true" values of some of them. Further, we have data on all the exogenous variables (x_i) and some missing data on the endogenous variable (y_i^*). Examining from above (right) is the case with a limit that on the threshold a value can take so that the true value might be equal to the threshold although it might also be higher. As regards examining from a lower limit, values that fall at or below that threshold level are censored.

For example, to evaluate the housing expenditure of a family on its income, there is the need to find out the amount a family spends on a house in relation to some socio-economic variables. If a family does not possess a house, we do not have data on housing expenditure; only those families with houses would have data on how much they spend on a house. Thus, we have two sets of respondents; $m_1$for those with whom we have data on both the endogenous (amount of housing expenditure) as well as the exogenous (socio-economic variables such as income, mortgage interest rate etc.) on one hand and m_2 that is those with whom we have data on only the exogenous but not the endogenous. We cannot estimate only $m_1$using OLS as it would give both biased and inconsistent estimates. The bias stems from the fact that $E(u_i)$ would not be zero and if $E(u_i) \neq 0$, the OLS estimates would be biased. Stable estimates can be attained by using the Tobit model which is a special case of the generalized censored regression model. This is because all the efficiency indices have 1 as an upper bound and 0 as a lower bound and therefore can be estimated by maximum likelihood using a Tobit model (Bravo-Ureta and Pinheiro 1993; Coelli, et al., 2002).

2.6.1 Review of Empirical Studies on Domestic Resource (DRC) Ratio and Data Envelopment Analysis (DEA) Model

This present study seeks to analyse the competitiveness of local rice production considering efficient utilisation of domestic resources (production technologies). In this regard, a review of empirical studies with DRC ratio which is a measure of the competitiveness of a sector and the DEA model which is one of the efficiency measures.

2.6.2 Empirical studies on the domestic resource cost ratio

The DRC ratio was first propounded by Michael Bruno (1967) as cited in Monke, (1981). The author used actual market prices to evaluate the domestic resource cost relative to the foreign exchange earned. Subsequent to Bruno's work, Pearson (1976) adopted the shadow price approach to evaluate domestic resource cost and since then the two measures had gained recognition and has been widely applied in many studies to estimate the competitiveness and comparative advantage in several sectors. Among some of the studies which used the DRC ratio in either assessing competitiveness or comparative advantage include the work done by Raisunddin (2004), who made an assessment of the comparative advantage of rice vis-à-vis other agricultural products in Bangladesh. Net financial return, net economic return and domestic resource cost was estimated for the period 1996/97 – 1998/99. The net financial return was computed by prising output and input at the actual market price. The net economic return was computed with output and tradable input valued at world prices. Rice grown in Boro season had a comparative advantage as opposed to that which is a competing crop. It was also found that Bangladesh had a fantastic comparative advantage in the cultivation of vegetables as showed by low values of DRC, which fell 0.05-0.11 for many vegetables. The study promoted the need for public research investment in non-cereal crops as the country struggles for divergence and expansion.

Maji (1996) estimated the DRC ratio for Indian rice sector. He observed that the domestic resource cost ratio of less than one, which implied that a low domestic resource cost could generate a much higher value in foreign exchange through export.

In furtherance, Kikuchi et al., (2016) investigated the international competitiveness of domestic rice production in Uganda by estimating the DRC ratio. It was concluded that, the domestic rice production which produced a significant (95 percent) of the national basket, did not have a comparative advantage with the rice imported from Pakistan.

An akin study by Adjao (2011) in analysing the competitiveness of the rice sub-sector in Mali discovered that Mali has a distinctive opportunity cost in the production and marketing of rice as against importing rice into the country.

In another study conducted by Minh et al., (2016), the authors applied the DRC ratio to evaluate the level of competitiveness of Dak Lak Coffee in Vietnam. They discovered that Coffee production in Vietnam had competitive advantage though the product was highly sensitive to price fluctuations.

Likewise, in Ghana Dzudzor (2012) analysed rice production and opportunities in Ghana and observed that in spite of numerous government interventions, Ghana still heavily rely on imported rice to augment supply deficits.

A similar study by Addison et al., (2015) revealed that despite domestic rice producers had regular annual increases due to informal rice value chains, the domestic rice sector was not competitive owning to the poor quality of milling.

This study, however, seeks to assess the competitiveness of the local rice production and its contribution to food security in the Northern region of Ghana using the domestic resource ratio and input-oriented VRS data envelopment analysis methodologies.

2.6.3 Empirical studies on the data envelopment analysis

Measuring efficiency has been of high interest to numerous researchers with the sole aim to investigate the efficiency levels of various sectors. One of the standard methods used by many researchers to analyse efficiency is the data envelopment analysis. The DEA is preferred as is independent of the specification of the functional form for the production frontier as well as the normality of the inefficiency component. Ever since the publication of the first paper by Charnes et al., (1978), the data envelopment analysis has extensively been used in a range of sectors including healthcare, education, banking and agriculture among others.

In the health sector, Chilingerian and Sherman (1990, 1994) analysed the efficiency of physicians' in the provision of hospital services. Subsequently, Chang et al., (2004) studied the efficiency of Taiwan government-owned hospitals using data between 1990 and 1994. In the area of education, Johnes (2006) assessed the efficiency of 100 higher education institutions (HEIs) in the United Kingdom. He used the output-oriented DEA because universities produce many outputs using many inputs. The outputs were graduate quantity and quality, postgraduate quantity and value of the periodic grant for research conferred by the Higher Education Funding Council for England in pounds sterling. He concluded that even though the English higher education sector had no profit motivation, the HEIs competed amongst themselves to attract the best students and research funds which provided incentives for efficiency.

Relative to agriculture, Shafiq and Rehman (2000) applied the input-oriented data envelopment analysis to examine input use inefficiency in cotton production in Pakistan's Punjab region involving a sample of 120 farm households. The authors reported that the farms had efficiency score within 80-100 percent range. The study also revealed a massive use of input such as phosphate fertiliser, labour and tractor hours which resulted in negative returns. The authors then recommended that the quantity of inputs use should be minimised to present level of output desired.

In the same vein, Rios and Shively (2005), studied farm size and efficiency in Vietnam coffee production using DEA revealed that, larger farms were more technically and cost efficient than smaller farms. The mean technical and cost efficiency estimates for the larger farms were 89 percent and 58 percent respectively with corresponding values for small farms as 82 percent and 42 percent.

Likewise, in Ghana Akramov and Malek (2012) examined the profitability of Maize, Rice and Soybean production in Ghana using Policy Analysis Matrix (PAM) and DEA. The authors found out that, maize farming system is mainly profitable under both average and profit-efficient production plans while soybean is not viable under the observed average production plan. Also, rice farming system is primarily not profitable if family labour is incorporated in domestic cost factor.

In another study in Northern Ghana, Abatania et al., (2012) applied the input-oriented DEA with bootstrapping to analyse the technical efficiency of farm households (maize, millet sorghum, rice and groundnut farmers). The authors found that 81 farms (42.9 percent of the sample) were technically efficient under VRS while 65 farms (34.4 percent of the sample) and 56 farms (29.6 percent of sample) were technically efficient under CRS and NIRS.

2.7 Conceptual framework

At the smallholder rice cultivation level, many variables influence competitive production and hence food security, a conceptual framework is presented in Figure 1. The main influencing variables include the efficiency with which domestic resources are utilised, production technologies in rice production, government policies about production technologies, expansion possibilities and market opportunities.

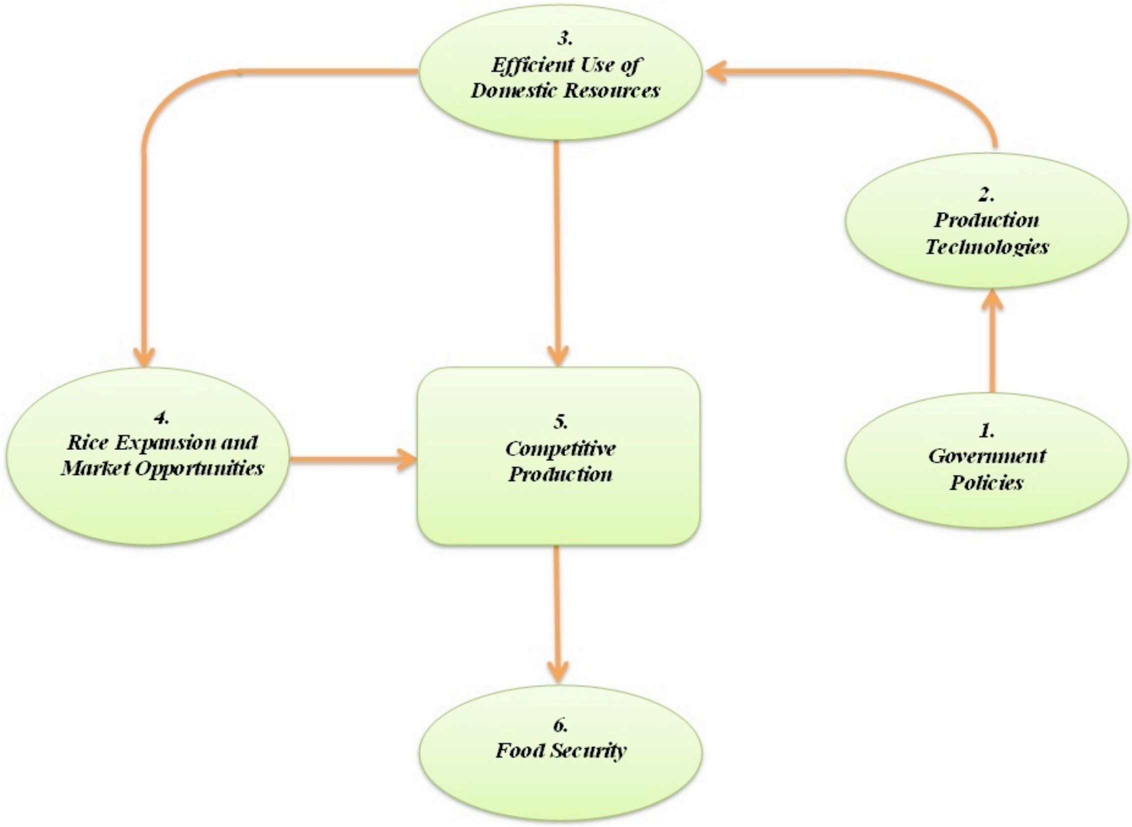

Figure 2: Conceptual framework

Source: Author's Construct (2017)

2.8 Problem Statement

Enhancing local rice production to meet the rapidly escalating national demand and reducing rice import has been of topmost priority for the government of Ghana. Policy approaches over the years as netted in FASDEP 1 &2, GPRS (1 & 2), MTADP, AAGDS of Ministry of Food and Agriculture policy have sought to encourage rice production to address food security and poverty reduction issues. FASDEP 2 which is one of the sector development policy guidelines, was aimed at decreasing rice imports by 30 percent and promoting the consumption of local rice through expanding production levels to 370,000 tons per year to safeguard food security and import replacement (MoFA, 2009).

Despite copious governmental policy interventions, domestic production of rice in the country has been woefully inadequate, thereby creating supply insufficiencies which is only met through imports (Ragasa et al., 2014; Addison et al., 2015). Such overdependence has grave consequences on Ghana's pursuit of food security, increased income and reduced poverty (Asravor et al., 2015). The question seeking answers to would be, how efficiently are domestic resources used in order to increase rice output and contribute significantly to food security in Ghana? Also, what is the competitiveness of the domestic rice sector in order to reduce rice imports? Against this backdrop, the study seeks to assess the competitiveness of local rice production and its contribution to food security in the Northern region of Ghana.

2.9 Aims of the thesis

In the context of increased debate on global and national food insecurity which has ostensibly compelled most developing countries to import rice among other food commodities in order to supplement domestic demand, this study sought to assess the competitiveness of local rice production and its contribution to food security in northern region of Ghana.

The specific objectives of the study are therefore to;

i. Assess the competitiveness of local rice production in specifically Northern region of Ghana.
ii. Investigate rice expansion possibilities in the study area
iii. Identify market opportunities for local rice by comparing marketing margins in respect to different target markets and interviews with middlemen.
iv. Evaluate the efficiency of resource use in rice production.
v. Suggest recommendations towards strategies to achieve food security.

The following research questions were developed to help better explain the objectives of the research and to streamline the research to its main aim.

i. What is the competitiveness of the local rice sector in the study area?
ii. Does the area stand a chance of expanding local rice production?
iii. What are the market opportunities considering the marketing margins at different target markets with the involvement of middlemen?

iv. What is the efficiency of resource use in rice production?

v. What possible recommendations could be made to achieve food security in the study area?

2.9.1 Study hypothesis

The study aims to test if socio-economic variables elucidate the presence of technical inefficiencies among small-scale rice farmers in the area. The maximum likelihood ratio test is used to test this hypothesis considering the chi-square value of both the null and alternative hypothesis.

1. Socio-economic variables do not elucidate the variations in technical inefficiency among rice farmers in the study area.

   H_0: $\beta_1 = \cdots \beta_6 = 0$

   H_A: $\beta_1 = \cdots \beta_6 \neq 0$

3. METHODOLOGY

3.1 INTRODUCTION

This chapter starts with a description of the study area as well as the sampling procedure and data collection. It also includes analytical framework, the empirical models of both the Domestic Resource Cost ratio and the Data Envelopment Analysis Model (DEA) as well as the theoretical framework and empirical model of the Tobit model.

3.2 Study area

The study was conducted in Savelugu-Nanton, West Mamprusi and Tolon districts of the Northern region of Ghana. The Savelugu-Nanton district is bordered on the north by West Mamprusi, to the east by Gushiegu-Karaga district, Yendi district to the south-east, on the west by Tolon-Kumbungu district and Tamale to the south. The district has a total land area size of 1,790.70sq km and it is 23km away from Tamale. It has an estimated population of 139,283, with males constituting 48.5 percent and females 51.5 percent (GSS, 2012). The district capital is Savelugu and agriculture is the predominant occupation of the area. The crops mostly cultivated include rice, maize, groundnut and soybean. Animals reared include cattle sheep, goat and poultry.

Walewale is the capital of West Mamprusi district. The district shares boundaries with Gushiegu and East Mamprusi districts to the east, it is surrounded to the north by Builsa, Kassena-Nankana east districts and Bolgatanga, bordered on the west by Mamprusi Moagduri and to the south by north Gonja, Savelugu and Kumbungu districts. The total land size of the area stands at 2610.44 sq. km and it has an estimated population of 121,117 (GSS, 2012). Females represent 50.8 percent of the population while 49.2 are males. The area lies in the guinea savannah zone consequently the vegetation comprises of short trees, grasses and shrubs. The area has an annual average rainfall of 900mm and temperature of 29 ^{O}C to 45 ^{O}C. The major occupation in the area is agriculture, mostly crops and animal production. The crops cultivated are rice, maize, sorghum, groundnut and beans among others. Animals such as goat, sheep, cattle and poultry are predominantly reared.

The Tolon district is bordered on the North by Kumbungu, North Gonja to the west, Central Gonja to the south and Sagnarigu districts to the east. The district has an estimated population of 72,990 (GSS, 2012). The vegetation is mainly grassland combined with guinea savannah woodland. It has drought resistant trees such as acacia (Acacia longifolia), mango (Mangifera), baobab (Adansonia digitata Linn), shea nut (Vitellaria paradoxa), dawadawa and neem (Azadirachta indica). The area has an annual average rainfall of 950mm-1200mm and temperature of 20°C to 39°C. The district capital is Tolon and agriculture is the predominant occupation of the area. The crops mostly cultivated include rice, maize, groundnut and soya bean. Animals reared include cattle, sheep, goat and poultry.

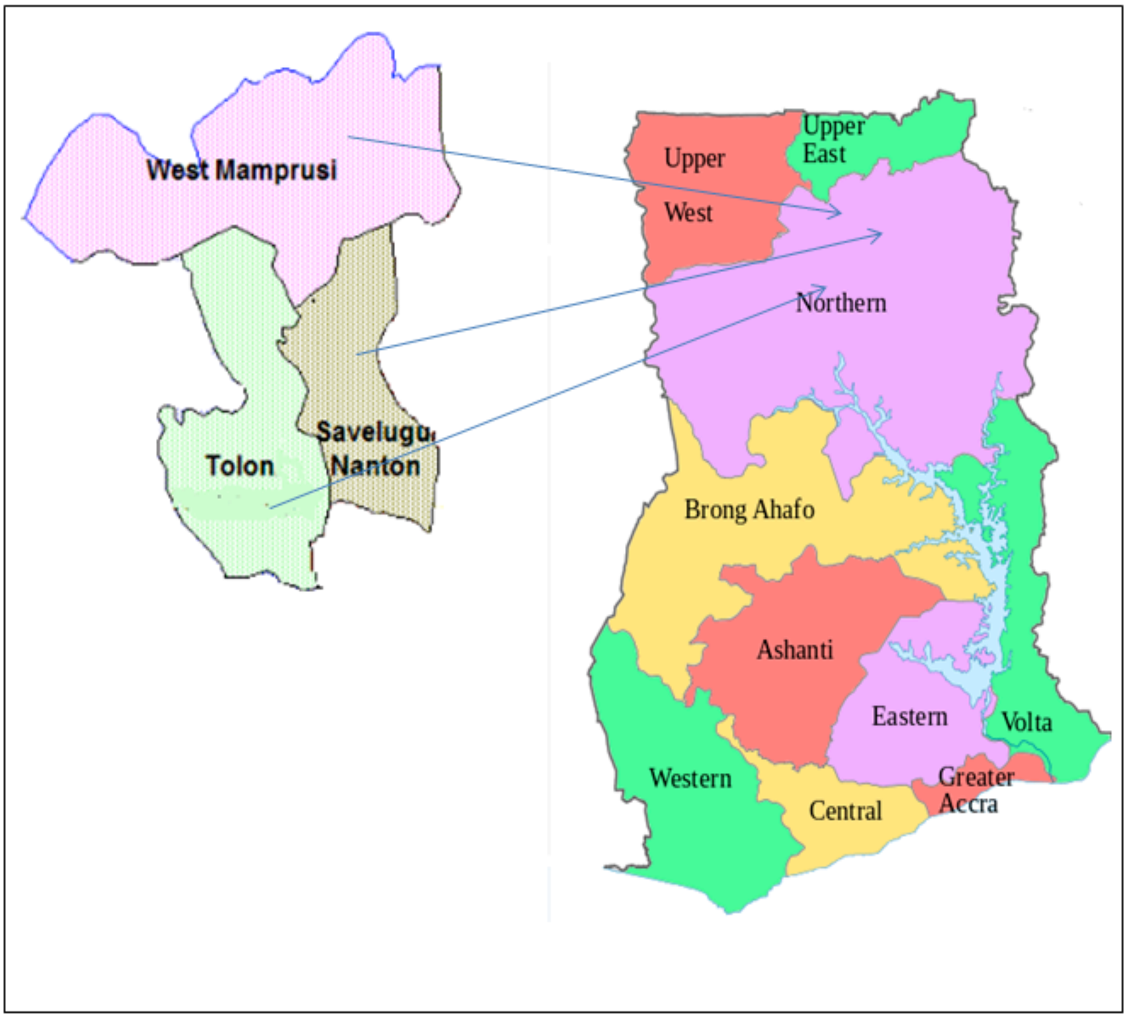

Figure 3: A map of Ghana indicating the Study Area

Source: Adapted from GSS, (2012)

3.3 Research Design

The study adopted the mixed model research approach where both the qualitative and quantitative research approaches were integrated. According to Creswell and Garrett (2008) a synergy of both the quantitative and qualitative research approaches give a detailed understanding of the phenomenon under study than either approach alone.

3.4 Data Categories and Sources

Primary data gathered for the study included the socio-economic and demographic characteristics of the small-scale rice farmers and middlemen, production technologies and financial support, economics of production, marketing systems, marketing margins involving middlemen, and economic prices of rice among others in the study area.
Secondary data was mainly obtained from Finatrade Ghana. Other secondary data were assembled from articles, journals and books. These data were obtained primarily for reviewing related literature.

3.5 Data Collection Instrument

The data collection tools that were employed to conduct the research include semi-structured questionnaires, interviews and focus group discussions.

3.5.1 Semi-structured questionnaire and interviews

According to Cohen and Manion (2011), questionnaires are essential tool which enable the researcher to attain significant information from numerous participants within the shortest possible time. In this regard, a set of close and open ended questions were used for interviewing respondents. It comprises information on the biodata and socio-economic characteristics of small-scale rice farmers and middlemen in study area. More importantly, information on farming and production system of rice cultivation were elicited using this tool, also the economics of production involving cost of inputs and other operational expenses and the quantity of paddy harvested and producer price from both the local market and farmgate were sought. Furthermore, production technologies and financial support encountered by the local rice producers were included in the semi-structured questionnaires. Finally, constraints and farming challenges that rare it ugly heads on these farmers were also included.

3.5.2 Focus group discussion

Eight experienced rice farmers in each district were randomly involved in a short focus group discussion regarding their interaction with middlemen and rural consumers who patronised the paddy rice. Also, information on the prices of paddy rice and the potential market opportunities considering the influx of imported rice in the local markets were elicited using this forum.

3.5.3 Key data variables for the study and their measurement

Variables are experiential property that takes different values or categories. In order to progress from the conceptual to the empirical level, theories are converted into variables. The main data variables for the research are farm size (in hectares), types of inputs used, sources of labour, access to finance, varieties of rice cultivated, production systems, land preparation method, farm gate and market prices of paddy and level of output. Other key variables include sources of extension services and marketing of farm produce as well as middlemen involvement in the rice supply chain

Two measurement scales were used to measure these variables. They are the nominal and interval scales. The nominal scale was used to measure the socio-economic characteristics of the sampled rice farmers such as level of education, gender, types of inputs used, farm preparation techniques and systems, fertiliser usage and access to credits, extension and markets.

The interval scale was used to measure the variables related to the farmers' land holdings (for instance farm size), years of farming, household size, quantities of agrochemicals used and farm output.

3.6 Sampling Technique and Sample Size

Purposive and simple random sampling techniques were used to select rice farmers and middlemen from the rice producing communities in the three districts. According to 2010 population and housing census (GSS, 2012) Northern region of Ghana had an estimated crop farmer population of 117,631. A sample size determination formula proposed by Miller and Brewer (2003) was adopted in calculating the sample size.

$$n = \frac{N}{1+N(e2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

n = sample size

N = population size

e = margin of error (fixed at 9.6%)

$n = \frac{117631}{1+117631(0.096)2}$ = 108 rice farmers for the three districts

Three communities were randomly selected in each district from which twelve rice households were also randomly sampled to get a total of 36 respondents for each district, thus making 108 rice farmers. Also three middlemen were randomly sampled from all nine communities within the three chosen districts, making total of 27 middlemen. Thus a total farm-level data was amassed from 135 households in all the districts of the study area as shown in Table 1. The reason for equal number of respondents was to have a fair comparison of results across these districts. The data were collected between August and September, 2016 in the Northern region of Ghana for the 2014/2015 cropping season.

Table 1: Sample distribution across districts and communities.

Name of District	Name of Communities	Number of Middlemen	Rice farmers	Number sampled per District
Savelugu-Nanton	Pong-Tamale, Gushie, Nabogu	9	36	45
West Mamprusi	Nasia, Janga, Kukuobila	9	36	45

Tolon	Golinga, Galinkpegu, Gbulahagu	9	36	45
Total	9	27	108	135

Source: Field survey, 2016.

3.7 Analytical Framework

Minh et al., (2016) applied the DRC ratio to evaluate the level of competitiveness of Dak Lak Coffee in Vietnam.

Also in assessing the competitiveness of domestic rice production in Uganda, Kikuchi et al., (2016) employed the DRC ratio, to evaluate the comparative advantage of Uganda's rice sub-sector relative to rice imported from Pakistan.

In another study, Adjao, (2011) analysed the competitiveness of Mali's rice sub-sector under two irrigation systems, used economic and financial profitability as well as Domestic resource cost ratio.

Similarly, this study used the DRC ratio to assess the competitiveness of local rice production in Northern region of Ghana and also employed the input-oriented VRS DEA to assess efficient use of technologies and resources in rice production.

3.7.1Theoretical framework of the Tobit model (censored regression)

In contrast to the stochastic frontier, where both the determinants of output and technical efficiency are computed concurrently, it is different for the DEA model. The predominant method in the development literature to find the drivers of technical efficiency gaps among DMUs is censored regression analysis because the efficiency scores have its minimum and maximum values at 0 and 1 respectively (Wouterse, 2008; Yong-bae and Choonjoo, 2010). The technical efficiency of each DMU is regressed on a set of socio-economic variables to explain the determinants of technical efficiency. It is given by:

$$y_i^* = X_i\beta + \epsilon_i$$ 3.12

$$y_i = \begin{cases} y^* & \text{if } y^* > 0 \\ 0 & \text{if } y^* \leq 0 \end{cases}$$ 3.13

where $\varepsilon_i \sim N(0, \sigma^2)$. y_i^* is an unobserved endogenous ("latent") variable, X_i is a vector of explanatory variables, β is a vector of unknown parameters, and ε_i is a disturbance term.

3.7.2 Empirical model of the domestic resource cost ratio

The DRC ratio is estimated as the ratio of the economic value of "domestic resources" used in production relative to the economic value-added created by the production process. Considering Salinger (2001) the domestic resource costs earned or saved by producing product j is defined as:

$$\text{DRC} = \frac{\sum s\, f_{s,j}\, P_s^*}{P_j^* - \sum i a_{i,j} P_i^*}$$ 3.14

where: $f_{s,j}$: quantity of factor of production s used to produce one unit of product j

P^*_s: international reference price of factor of production s

P^*_j: international reference price of product j

$a_{i,j}$: quantity of tradable input i used to produce one unit of product j

P^*_i: international reference price of input i

The DRC thus represents the cost of domestic resources spent in order to gain or save a unit of foreign exchange. In order to see whether a country is efficient in the production of product j, the DRC should be compared to the shadow exchange rate which reflects the scarcity value of the foreign exchange for the entire economy, that is the reference exchange rate (Salinger, 2001). A DRC coefficient which is greater than 1.00 suggests that the firm is using more value in domestic resources than it is gaining in tradable value-added. A DRC coefficient which is less than 1.00 suggests the opposite, that is the firm is gaining more in terms of tradable value-added than it is using in domestic factors of production. In the latter scenario, the firm is said to be competitive and demonstrates a comparative advantage, relative to other global producers, in the production of that good.

The DRC ratio provides a primary scale of the opportunity cost and competitiveness for initial examinations (Siggel, 2006).

3.7.3 Empirical model of the input-oriented VRS data envelopment analysis

Coelli et al., (1998) posited CRS data envelopment analysis model is only suitable when all firms are operating under optimal scale however, imperfect competition or constraints such as finance may influence decision making units not to operate at optimal scale hence the VRS DEA model was chosen for this research as it is more adaptable and encases the data sets more closely than the CRS DEA. The variable returns to scale yields three main efficiencies namely the Overall Technical Efficiency (OTE_{CRS}), Pure Technical Efficiency (PTE_{VRS}) and Scale Efficiency (SE). The latter deals with the scale of operation of individual decision making units. If the value of scale efficiency = 1 then the decision making units is scale efficient and if less than one, then decision making unit is scale inefficient. However, scale efficiency is the proportion of the overall technical efficiency (OTE_{CRS}) to the pure technical efficiency (PTE_{VRS}) Dhungana et al., (2004). Considering Coelli et al, (1998), input-oriented VRS data envelopment analysis model is given by

$$\min_{\theta,\ \lambda} \theta$$

$$st— y_i + Y\lambda \leq 0 \ldots\ldots 3.15$$

$$\theta x_i — X\lambda \geq 0 \ldots\ldots 3.16$$

$$N1^{!}\ \lambda = 1 \ldots\ldots 3.17$$

$$\lambda \geq 0 \ldots\ldots 3.18$$

where θ is a scalar λ is a N×1 vector of constants and M is an N×1 vector of ones. The resultant value of θ attained will be the estimated efficiency scores for the individual (i-th) decision-making unit. it will satisfy θ ≤ unity, with a value of 1 depicting a point on the frontier and hence technically efficient decision-making unit, as posited by Farrell (1957). That is, the linear programming problem under study needs to be solved N times and a value of θ is provided for each decision-making unit in the sample.

3.7.4 Empirical model of the Tobit regression (censored regression)

The Tobit model is deployed because it allows for censoring of the limited dependent variable (efficiency scores). Especially, in this case, where all the efficiency scores have 1 as an upper bound and 0 as a lower bound. The technical efficiency estimates of each DMU are regressed on a set of socio-economic variables to elucidate the determinants of technical efficiency by maximum likelihood using a Tobit model.

$$Y_i^{*}=\beta_0+\beta_1 X_1+\beta_2 X_2 +\beta_3 X_3+\beta_4 X_4+\beta_5 X_5+ \beta_6 X_6+Ui \ldots\ldots\ldots\ldots 3.19$$

Where Y_i^{*} is the technical efficiency scores of the respondent obtained from the first stage analysis of DEA, pure technical efficiency scores; X_1 is the farm size (ha); X_2 is access to agricultural mechanisation (dummy 1= yes and 0 = no); X_3 is the number of family hands on the rice farm; X_4 is number of extension contact; and X_5 is the years of experience in rice cultivation; X_6 is the years spent in education; U_i is the stochastic disturbance term and β is the vector of parameters to be estimated.

3.8 Tools for data analysis and test of research hypothesis

The econometric software STATA version 12 was employed to analyse the Tobit regression model while microsoft excel was used in computing the DRC ratio and for constructing frequency tables and charts. Also, MaxDEA 7 basic, was used to analyse the DEA model while oneway Analysis of Variance (ANOVA) was used to test the statistical significance of input use between efficient fand ineffcient rice farmers. However, the research hypothesis was tested using the likelihood ratio test. The generalised likelihood-ratio test was of the form:

$$k =-2[ln\{L(HA)\}/ln\{L(H0)\}] = -2[ln\{L(HA)\}\text{-}\ ln\{L(H0)\}] \ldots\ldots\ldots 3.20$$

where $L(H_A)$and $L(H_0)$ are the values of the likelihood function under the alternative and null hypotheses. The value of k has a Chi-square, $\chi 2$ (or mixed chi-square) distribution with the number of degrees of freedom equal to the difference between the number of parameters involved in H_0 and H_A.

3.9 Limitations of the study

The only limitation of the study was the inability to obtain different FOB and CIF prices from assorted rice importing companies in the study area as most of these companies refused to provide the data needed. As a result, information from only one import company (Finatrade Ghana) was considered in the domestic resource cost ratio calculations in this study.

4. RESULTS

4.1 Introduction

This chapter entails the results of the Domestic Resource Cost (DRC) Model, Input-Oriented VRS Data Envelopment Analysis (DEA) as well as socio-economic characteristics and summary statistics of variables and respondents. It also contains farmer-middlemen interaction along the rice supply chain as well as marketing margins.

4.2 Socio-economic Characteristics of Respondents

In this section, we present the combined social and economic features of the main respondents (rice farmers) for all the three districts in the study area. Specific issues discussed include the educational status of respondents, sex of respondents, method of rice plot preparation, varieties of rice cultivated, types of farm labour used, access to tractor services for agric mechanisation, sources of agricultural extension services, access to credit, fertiliser subsidy and decision to cultivate rice, membership to association and its associated benefits.

4.2.1 Educational status of respondents

Findings from the study revealed that 54.6 percent of the respondents had never been formally educated in area. However, a majority (35.2 percent) of respondents with formal education attained basic education (primary and JHS education) while 7.4 percent had senior high school (SHS) education. This implies that, only 45.4 percent of respondents were literate and 54.6 percent could neither read nor write (Table 2).

Table 2: Educational status of respondents

Educational Status	Frequency	Percent
No formal education	59	**54.6**
Primary education	26	24.1
JHS	12	11.1
SHS/Vocational/Technical	8	7.4
Tertiary	3	2.8
Total	**108**	**100**

Source: Field survey, 2016.

4.2.2 Sex of respondents

The majority of the respondents were males (63.9 percent) while their female counterparts accounted for only 36.1 percent as shown in figure 4.

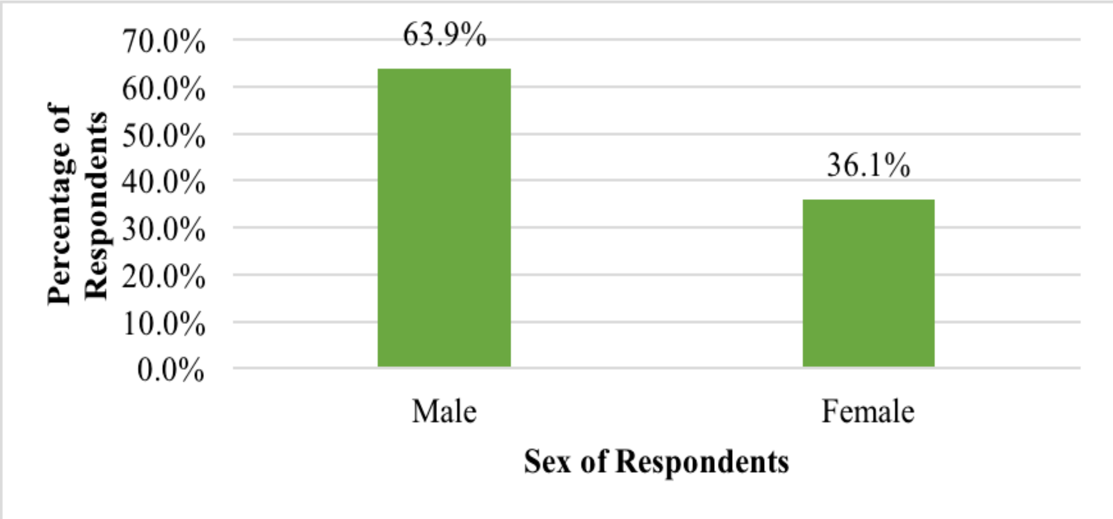

Figure 4: Sex of respondents

4.2.3 Method of rice land preparation

The study identified the use of farm tractor as the main method of land preparation for rice in the study area. Majority about 98 farmers, representing 90.7 percent used farm tractor for ploughing their lands. However, the use of bullock service for ploughing farmlands was also common as few (10) representing 9.3 percent of the farmers as used this method (Figure 5).

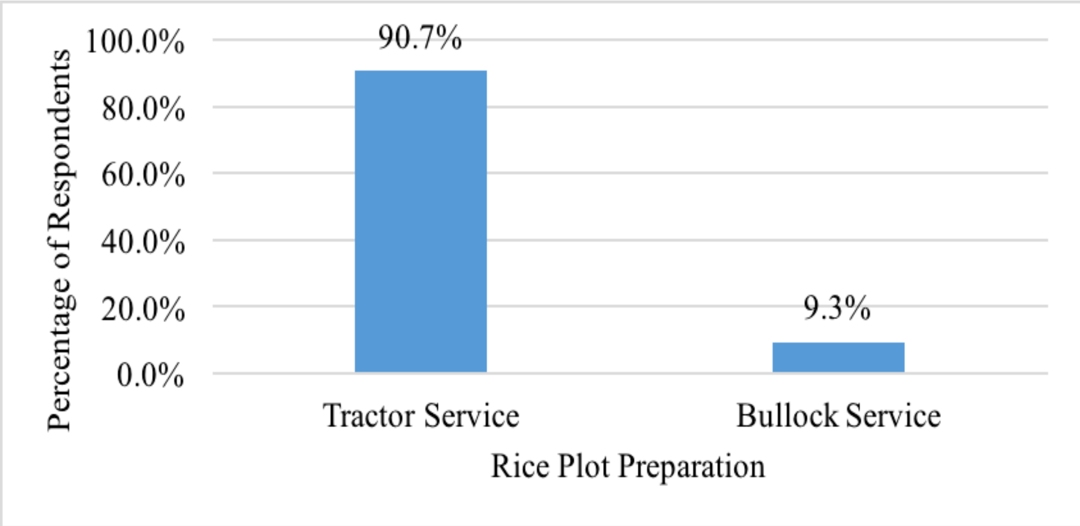

Figure 5: Method of rice plot preparation

4.2.4 Varieties of rice cultivated by respondents

Good seed is an indispensable ingredient in productive agriculture as it is the starting point for all crop cultivation. Mandii which is considered a local variety was mostly (18.5 percent) cultivated by respondents. This variety in addition to others, was often selected from the harvest and stored as planting seed for the next season. Among the varieties of rice cultivated, Jasmine 85 and Togo Marshall were the aromatic type and often purchased by farmers every season for cultivation. These types of varieties were also used by 16.7 percent and 4.6 percent of the farmers respectively while 17.6 percent, 10.2 percent and 9.3 percent of respondents cultivated Salmasaa and AGRA, Abirikukuo respectively as shown in Table 3.

Table 3: Varieties of rice cultivated by rice farmers

Rice varieties	Frequency	Percent
Jasmine 85	18	16.7
Tox	9	8.3
Salmasaa	19	17.6
Mandii	20	**18.5**
Afife	16	14.8
Togo Marshall	5	4.6
AGRA	11	10.2
Abirikukuo	10	9.3
Total	**108**	**100.0**

Source: Field survey, 2016.

4.2.5 Farm labour used by respondents

Household labour was the main source of labour for rice cultivation in northern region of Ghana and when it was not enough, hired labour was sought. From Figure 6, 60.2 percent of households within the three districts depended on labour from their families while 21.3 percent and 18.5 percent respectively relied on hired labour and group labour during rice cultivation activities. Group labour is when farmers work on one another's farms during peak labour demand periods.

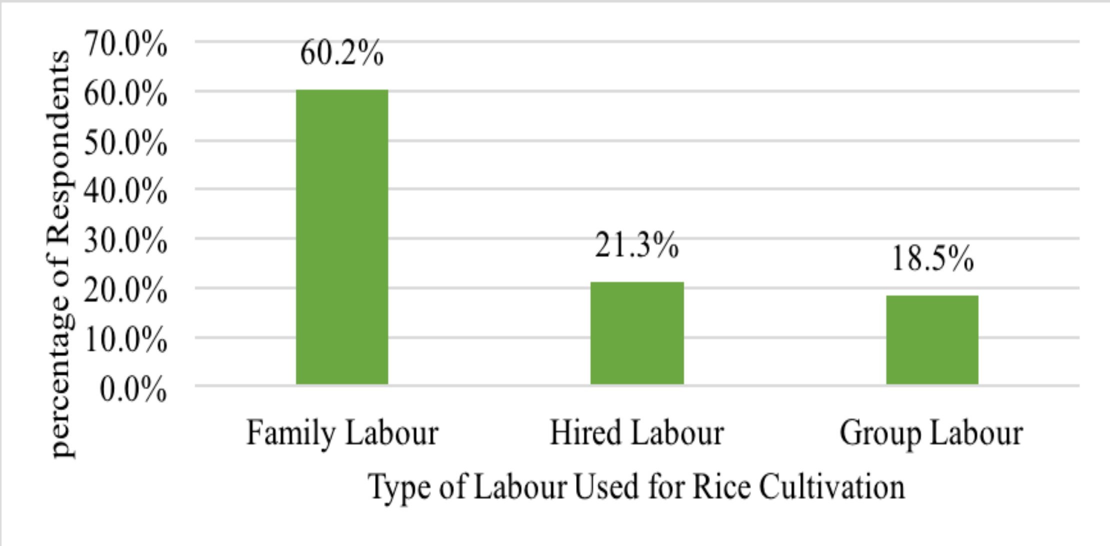

Figure 6: Type of farm labour used in rice cultivation

4.2.6 Access to tractor services for agricultural mechanisation

The majority (26.9 percent) of the respondents had access to and expended the farm tractor for ploughing and harrowing their farmlands. Also 19.4 percent of the respondents use the tractor for ploughing, harrowing, threshing and carrying harvested paddy rice from the farm to their house while 17.6 percent use the tractor only for ploughing services (see details in Table 4).

Table 4: Access to tractor services for agricultural mechanisation

Access to tractor services for agric. mechanisation	Frequency	Percent
Ploughing	19	17.6
Ploughing and harrowing	29	**26.9**
Ploughing and threshing	17	15.7

Ploughing and carrying farm produce	10	9.3
Ploughing, harrowing and carrying farm produce	12	11.1
Ploughing, harrowing, threshing and carrying farm produce	21	19.4
Total	**108**	**100.0**

Source: Field survey, 2016.

4.2.7 Sources of agricultural extension service

The majority (58.3 percent) of the farmers received agricultural extension service from government paid extension agents underscoring the role of Ministry of Food and Agriculture (MoFA) in extension delivery. Others (13.9 percent) obtained extension service from other government institutions and interventions such as the Savannah Agricultural Research Institute (SARI), Millennium Development Authority (MiDA) and Alliance for a Green Revolution in Africa (AGRA). Meanwhile, 27.8 percent of the respondents did not have access to agricultural extension service as shown in Figure 7.

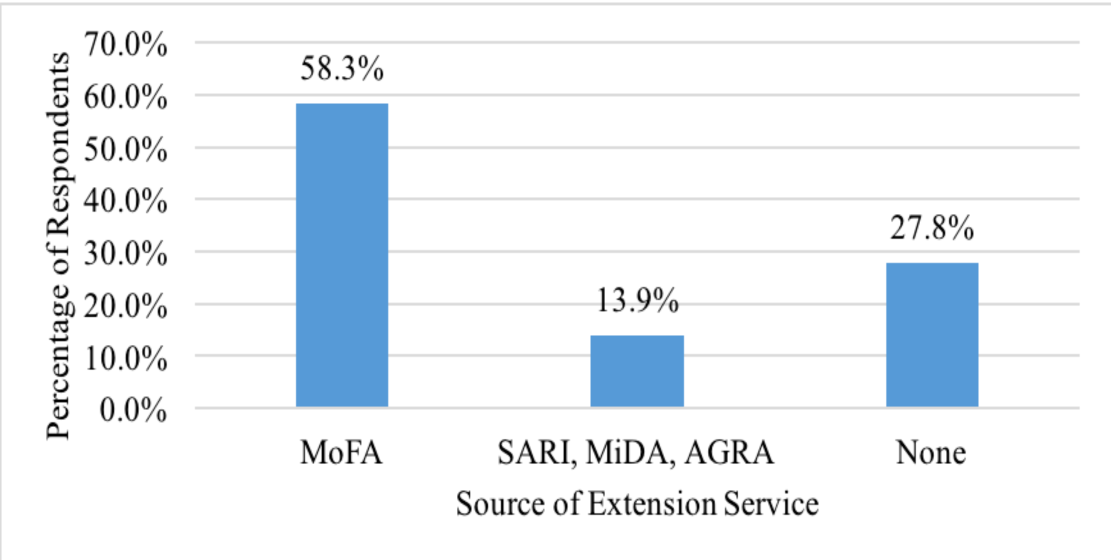

Figure 7: Source of agricultural extension service

4.2.8 Access to credit support

A total of 70 respondents representing 64.8 percent did not have access to credit facilities to facilitate purchasing of improved inputs to maximise rice output as opposed to 35.2 percent who had access to credit facilities. To this end, most of the smallholder rice farmers had to borrow from relatives, friends, middlemen and traders as opposed to formal sources (Figure 8).

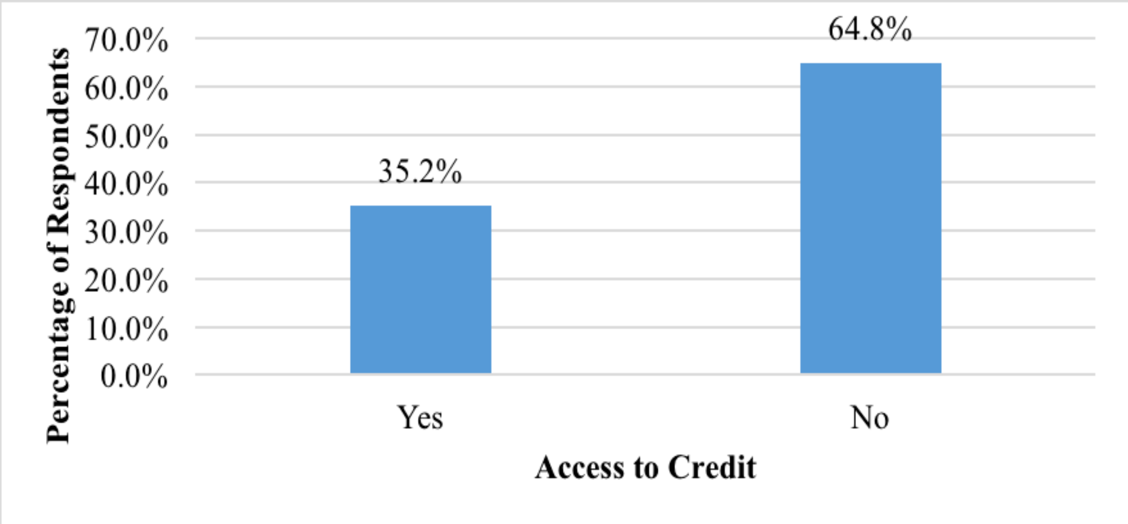

Figure 8: Access to credit support

4.2.9 Fertiliser subsidy and decision to cultivate rice

The chunk (77.8 percent) of the respondents attributed their decision to cultivate rice on the fertiliser subsidy as it reduced their cost of production. Conversely, 22.2 percent thought otherwise as depicted in Figure 9.

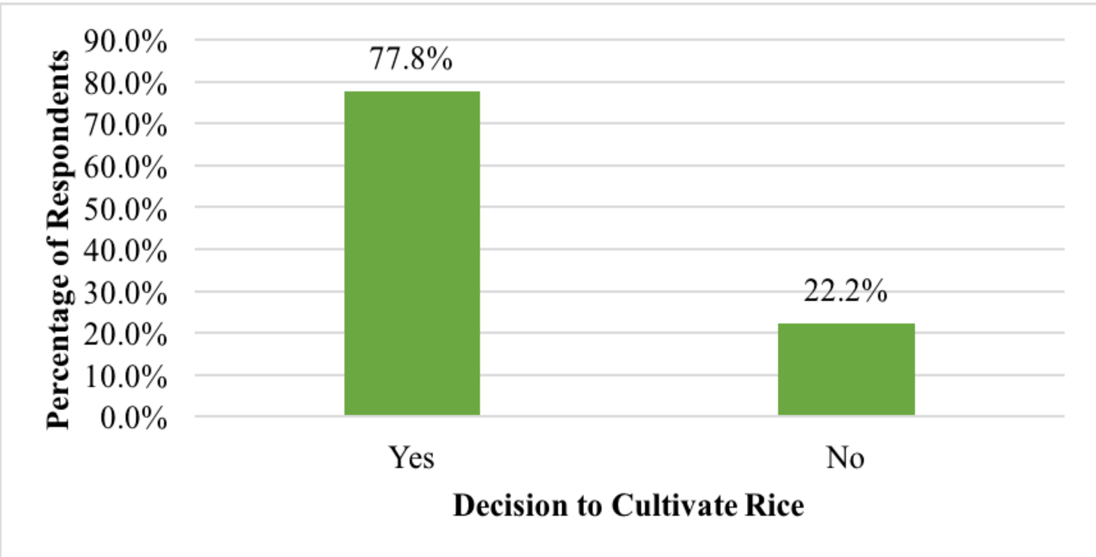

Figure 9: Fertiliser subsidy and decision to cultivate rice

4.3 Membership to farmer association

There is no denying the fact that farmers who belong to associations stand higher chance of accessing credit support, group labour, group extension services and among others. Figure 10 revealed that more than half (60.2 percent) of the respondents belonged to farmer associations as opposed to 39.8 percent.

Figure 10: Membership to farmer association

The study found that majority (38 percent) of the respondents derived group extension as member benefit. This was derived from the organised groups liaising with extension agents who operate in their localities. More importantly, group labour is the most beneficial reason farmers' join associations with the sole aim of complementing family labour due to inability to afford the services of hired labour. This benefit was highly necessary and evident during planting and harvesting periods. Thirdly, 25.9 percent of the respondents who belonged to group, accessed production inputs timely due to their organised nature and ease of tracing them in terms of default. The details of member benefits identified in the study are depicted in Figure 5.

Table 5: Benefits of membership to association

Benefits of membership to association	Frequency	Percent
Group extension	41	**38.0**
Timely access to production inputs	28	25.9
Group labour	24	22.2
Support in times of need	15	13.9
Total	**108**	**100.0**

Source: Field survey, 2016.

4.3.1 Definition and summary statistics of variables

Table 6 shows the combined descriptive statistics of the variables used in the study in terms of their mean, standard deviation, minimum and maximum values. In all, a total of 16 variables out of which 6 were used in the data envelopment model and included farm size, seed, fertiliser, labour, herbicides and yield whereas 7 variables namely international reference prices of rice, fertiliser, rice seeds, herbicides and their quantities were used in estimating the domestic resource cost ratio.

Table 6: Summary definition of variables and descriptive statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Age of farmer (Years)	**40.56**	10.14	25.0	75.0
Gender (Dummy; 1 for male, 0 for female	**0.64**	0.48	0.0	1.0
Education (Years)	**3.75**	4.55	0.0	15.0
Household size (number of family members)	**9.50**	5.39	2.0	30.0
Farm size (Land) (ha)	**2.36**	3.11	0.4	19.2
Experience (Years)	**10.78**	6.90	2.0	30.0
Extension contact (number)	**4.92**	5.19	0.0	12.0
Family hands (number of household members that work on rice farm	**4.02**	2.78	1.0	15.0
Credit (GH¢)	**566.28**	960.67	0.0	5,000.0
Quantity of hired labour	**15.09**	5.54	9.0	44.0
Wage of hired labour (GH¢/day)	**12.86**	2.99	2	20.0

Fallow period (Years)	**5.00**	2.60	2.0	10.0
Transport cost 50kg (from farm to farmer's house) (GH¢)	**4.36**	1.03	3.0	8.0
Rice seed (quantity used) (kg/ha)	**312.17**	504.38	45	4,320.0
Herbicides (litres/ha)	**7.85**	8.66	1	48.0
Cost of herbicides (GH¢/litre)	**18.25**	7.24	9	40.0
NPK (Kg/ha)	**217.13**	296.25	0	1,500.0
Cost of NPK (GH¢/50kg bag)	**90.05**	30.63	0	105.0
Urea (Kg/ha)	**140.50**	199.90	0	1,000.0
Cost of urea (GH¢/50kg bag)	**77.59**	26.34	0	90.0
Rice output (Kg/ha)	**2,760.64**	3648.59	300	25,700.0
Farm gate price of rice (GH¢/50kg bag)	**83.00**	16.57	60	130.0
Market price of rice (GH¢/50kg bag)	**93.65**	17.22	70	140.0

Source: Field survey, 2016.

Findings from Table 6 identified that, the average age of a household head was about 41 years. This shows that rice farming is mainly practiced by the middle-aged group. The average farm size of 2.36 hectares (5.9 acres) was slightly higher than the 2 hectares reported in the MoFA, (2013) that most rural farm households operate with quite smaller land holdings. Further, the study found a higher mean household size of 9.50 compared with 5.8 obtained in the 2010 census by the Ghana statistical service for northern region.

The study recorded a mean farming experience of 10.78. Meanwhile, the average extension contact was 4.92 times, which implies that basically, the rice farmers were visited approximately five (5) times in a year by government paid extension officers or by an NGO. The average fallow period in the study area was five (5) years which implies that a typical farmer leaves the farmland to regain it fertility for five cropping calendars.

Moreover, the average quantity of rice seed used in cultivation was 312.17kg. This implies that a household would need 312.17kg (104 bowls) to sow 2.36 hectares (about 5.9 acres) of land. Similarly, a household on average required 7.85 litres (7.9 bottles of herbicides to apply on 2.36 hectares of farmland to control weeds. The mean values of NPK and urea fertilisers were 217.13 (4.3 bags) and 140.50 (2.8 bags) respectively. This means that a household require about a little more of 4 bags of NPK and nearly 3 bags of urea to apply on 2.36 hectares of farmland in order to obtain a yield of 2760.64kg (about 55.21 bags) of rice. Also, a household on average received a credit amount of GH¢ 566.28 which could fairly support rice production. According to the findings, a 50kg of paddy rice is sold averagely at GH¢ 83.00 and GH¢ 93.65 at farm gate price and market price respectively.

4.3.2 Socio-demographic characteristics of middlemen in the study area

Results from Figure 11 explicitly shows that majority (59.3 percent) of the middlepersons who purchase paddy from the small-scale rice farmers were females. However, quite appreciable number (40.7 percent) were males, emphasizing that not only women are involved in the rice supply chain process within the area.

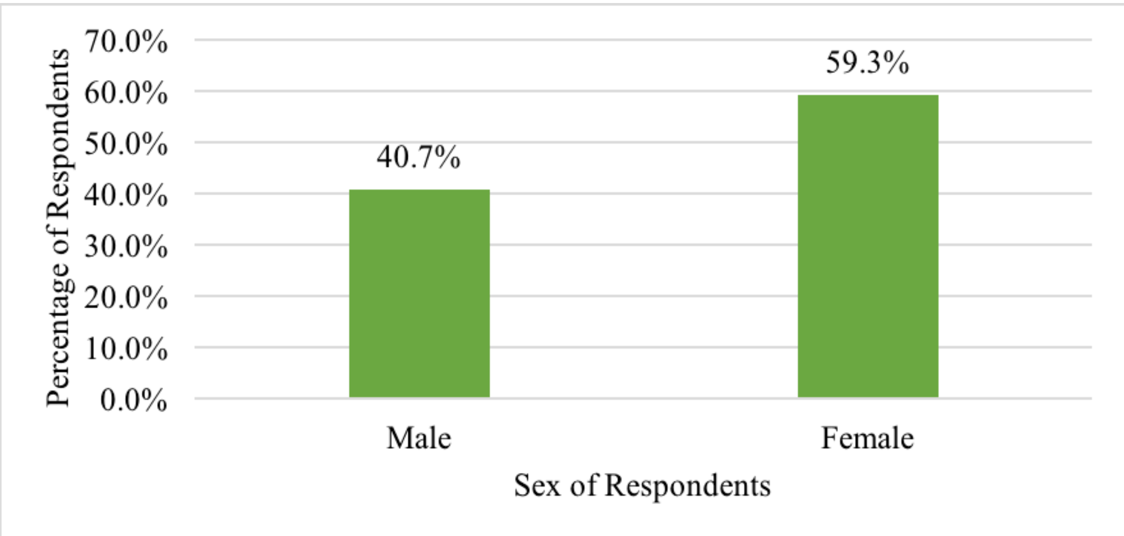

Figure 11: Sex of middlemen in the study area.

Evidently, the mean age of the sampled middlemen from the study was 43 years, which means that middlemen were in their economically active age bracket. This stress the fact that matured people are those involved in the rice supply chain, since purchasing paddy entails numerous bargaining with rice producers which is meant for experienced and matured traders. The educational status according to the findings of the study, revealed that at least middlemen had basic (primary) education as approximately 3 years was spent at the primary level of education (Table 7). This implies that at least they could read nor write which could assist them in keeping records of their purchases and other marketing activities. Averagely, the quantity of paddy purchased from the small-scale rice farmers by middlemen was 66.56 bags (3,328kg) which is a good indication of higher yields considering the average number (12) of middlemen which serve each community and the fact that the average yield obtained from the study (2.8 tons/ha) was slightly higher than the national average (2.5 tons/ha) recorded in 2012/2013 cropping calendar even though it was lower than the achievable yield of 6.5 tons/ha in the experimental fields according to Crops Research Institute (MoFA, 2013).

Table: 7: Key variables and demographic characteristics of middlemen in the study area.

Variable	Description	Mean	Std. Dev.	Minimum	Maximum
Age	Number of years of respondents	**43.00**	5.22	35	54
Sex of middlemen	Dummy; 1for male, 0 for female	**0.59**	0.50	0	1
Educational status	Number of years of formal education	**3.22**	3.52	0	9
Quantity of paddy (in 50kg bag)	Quantity of paddy purchased during the entire season	**66.56**	46.17	20	180
Number of middlemen	Number of middlemen that serve each community	**12.41**	5.05	6	25
National price of paddy	National average price of 50kg paddy	**118.52**	10.54	100	140

Source: Field survey, 2016.

4.3.3 Results of Objective one

International reference price (CIF) of rice according to importing company (Finatrade) was $420/Mt for 100 percent broken rice and $513.60 for 5 percent broken rice from Vietnam. Due to the poor quality of the locally produced rice in Ghana, rice imported from Vietnam among that of the USA and Thailand was chosen for the calculation of the DRC ratio due to its lesser quality and lower price compared to the other two.

Imported rice in the country attracts the following duties and levies; 20 percent import duty, 17.5 percent value added tax, 2.5 percent national health insurance level, 0.5 percent export development and investment fund, 1 percent Inspection fee, 0.5 percent ECOWAS Levy, 0.4 percent GCNET (USDA, 2014). Based on the above duties and levies rate, the international reference price $420/Mt attracts $84, $73.5, $10.5, $2.1, $4.2, $2.1 and $1.68 for import duty, NHIL, EDIF, Inspection fee, ECOWAS levy and GCNET respectively.

Therefore, the international reference price of Vietnam imported rice is **$598.08/Mt,** applying the exchange rate yields = GH¢ 2,272.70

The amount of money required to meet the expenses on hired or purchased inputs was considered as operating capital in this study. Interest on operating capital was calculated using the formula proposed by Mia el al., (2013) given by equation 4.1

$$IOC = AIit \ldots\ldots 4.1$$

Where IOC= Interest on operating capital

i= rate of interest, on the average amount of loan either borrowed from formal and informal sources = 8.75 percent from field survey with rice producers.

AI= Total investment/2, which case is the average amount of capital borrowed = 566.28

T= Total time period of a cycle, in which case is period of loan repayment for paddy producers by lenders in this study = 6 months

IOC = 566.28/2*0.0875*6= GH¢ 148.65

For fixed capita depreciation of land (domestic factor), findings from the study reveal that farm land is family owned in the study area and in cases when it is rented out, cash is collected in terms of one-third of the proceeds (paddy rice). Bearing in mind the average paddy of 2,760.64kg (2.7 tons/ha) therefore, one-third of 2,760.64 equals 920.21kg and is equivalent to 18.40 bags (50kg) of paddy rice. The market average price of paddy from the field survey was GH¢ 93.65. This translates into 18.40*93.65 = GH¢ 1,723.16

In order to calculate for the depreciation of the fixed asset (farm land), the double-declining balance method was used.

The lifespan of farm land according to this study was considered in terms of the average fallow period (as proxy for land fertility) was five (5) years from the field survey. Therefore, depreciation rate

$= \frac{100}{5}*2 =$ 40%, hence the depreciation value of the asset (farm land) is given by 40%*1,723.16 = GH¢ 689.26

In effect, the DRC ratio according to equation 4.1 and using figures from Table 7

$$DRC_j = \frac{\sum s\, f_{s,j}\, P_s^*}{P_j^* - \sum ia_{i,j} P_i^*} \qquad \text{.....4.2}$$

$$\frac{(194.06+148.65+689.26+350.72)}{2{,}272.70-(300.05+520.80+281+143.26)} = \frac{(1{,}382.69)}{(1{,}027.59)} = \mathbf{1.35}$$

Results from the DRC ratio suggest that the local rice production in the study area is not competitive and domestic resources are not efficiently used hence the sector does not have comparative advantage with other global rice producers.

Table 8: Results of the domestic resource cost ratio

Tradable inputs			**Non tradable inputs**		
Item	Price	Cost (GH¢)	Item	Unit	Cost
Certified seeds	85.00	300.05	Labour	Md/ha	194.06
NPK	120.00	520.80	Capital*	GH¢	148.65
Urea	100.00	281.00	Land	Ha	689.26
Herbicides	18.25	143.26	Other expenses**	GH¢	350.72
Total (**a**)		**1,245.11**			**1,382.69 (c)**
Int. price of rice (b)	**2,272.70**	**2,272.70**			
DRC=(**c**)/(b-**a**)		**1.35**			

Source: Farm-level data and USDA, (2014). Note: For all quantities of inputs used refer to table 4.5; Official Exchange rate (OER): 1US $ = GH¢ 3.8 (Bank of Ghana as at December, 2015).

**Other expenses refers to the average cost (GH¢ 4.36/50kg) of paddy rice as transportation cost from farm gate to the farmers' house and the average cost of a sack (GH¢ 2/bag) for paddy rice. Estimated based on the average yield for the study.
*Capital interest refers to the interest on operating capital (interest on the average amount of credit borrowed either from formal or informal sources for rice farming).

4.3.3.1 DRC ratio for efficienct farmers

Quantities of inputs used by efficient farmers include 1.68ha, 82.50kg, 248.81kg (164.29kg NPK and 84.52kg Urea), 5.67litres, 10.52 for land, certified seeds, fertilizer, herbicides and labour respectively (refer to table 6). Applying the same price as used for tradable inputs and cost of non-tradable inputs (as shown in Table 8). The DRC ratio is given as

$$DRC_j = \frac{\sum s\ f_{s,j}\ P_s^*}{P_j^*\ \text{-}\sum ia_{i,j} P_i^*} \quad \text{...}4.3$$

$$\frac{(135.29+148.65+689.26+350.72)}{2{,}272.70-(155.55+396.00+170.00+103.48)} = \frac{(1{,}323.92)}{(1{,}447.67)} = \mathbf{0.91}$$

Table 9: Results of the domestic resource cost ratio for efficient farmers

Tradable inputs			**Non tradable inputs**		
Item	Price	Cost (GH¢)	Item	Unit	Cost (GH¢)
Certified seeds	85.00	155.55	Labour	Md/ha	135.29
NPK	120.00	396.00	Capital*	GH¢	148.65
Urea	100.00	170.00	Land (ha)	Ha	689.26
Herbicides	18.25	103.48	Other expenses**	GH¢	350.72
Total (**a**)		**825.03**			**1,323.92 (c)**
Int. price of rice (b)	**2,272.70**	**2,272.70**			
DRC=(**c**)/(b-**a**)		**0.91**			

Source: Farm-level data and USDA, (2014)

4.3.4 Results of objective two

Findings from the study revealed that 79.6 percent of the respondents had the possibility of expanding their rice fields while 20.4 percent thought otherwise (Figure 12).

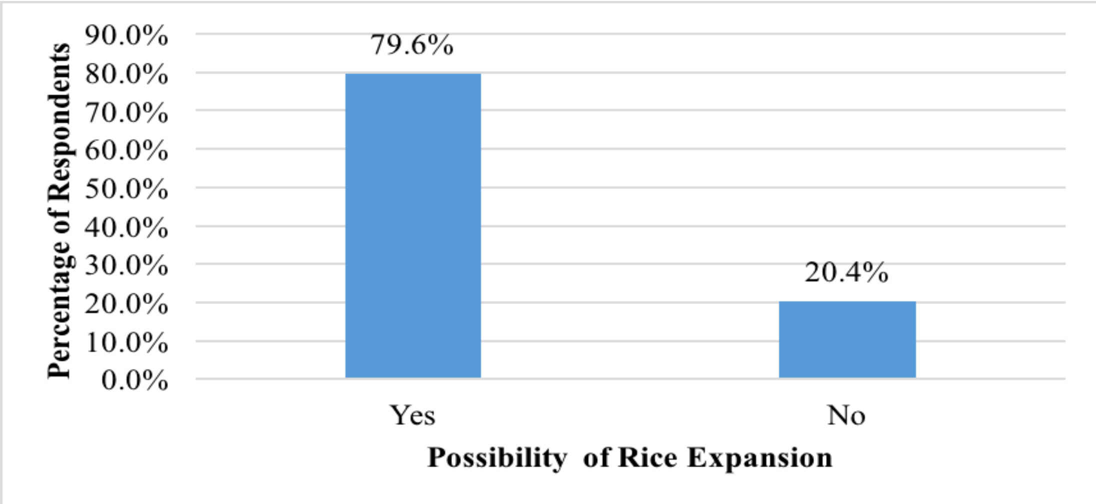

Figure 12: Rice expansion possibility by respondents

Explicitly the respondents allotted their motivation to expanding their rice fields mainly by having access to production inputs on credit, ability to access financial support, increase in crop yield, larger family size and most importantly having higher producer price (Table 10).

Table 10: Motivation for expanding rice fields

Motivation for expansion	Frequency	Percent
Access to production inputs on credit	27	25.0
Access to financial support	35	**32.4**
Increase in rice yields	24	22.2
Higher producer price	13	12.0
Increase in family size	9	8.3
Total	**108**	**100**

Source: Field survey, 2016.

4.3.5 Results of Objective three

It was observed that market opportunities exist for small-scale rice producers in the study area considering the average yield of 2.8 tons/ha (Table 4.6).

It is clear from figure 13, that majority (59.3 percent) of the small-scale rice farmers sell their paddy at farm gate due to their inability to afford high transportation cost. However, others (22.3 percent) offer their paddy for sale at the local market for a better price while a paltry of sell their paddy rice at both farm gate and local market.

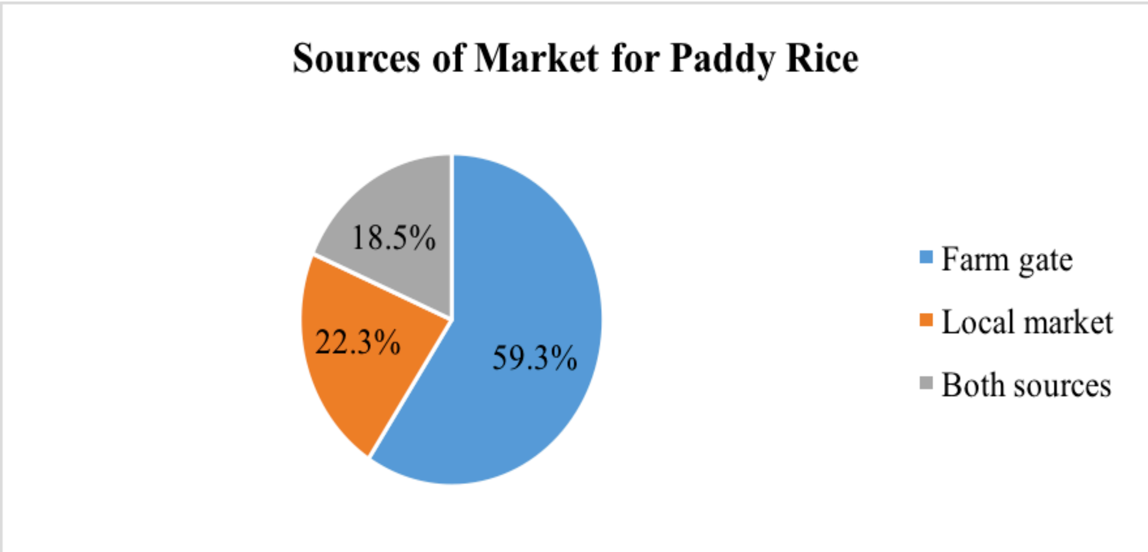

Figure 13: Sources of marketing for paddy rice.

Accordingly, the small-scale rice farmers were reluctant to sell their harvested paddy at farm gate price due to the low producer price. As high as 51.9 percent of the middlemen interviewed, indicated that paddy producers bluntly refused to offer their harvested rice for sale at farmgate while 29.6 percent also demonstrated unwillingness to sell at farmgate due to delayed payment and incessant bargaining by middlemen. Others (18.5 percent) felt cheated and exploited by middlemen as they lack access to better market information (Table 11).

Table 11: Reasons rice farmers divert paddy rice to local market

Description	Frequency	Percent
Low price offered by middlemen	14	**51.9**

Delayed payment by middlemen	8	29.6
Farmers feel cheated and exploited	5	18.5
Total	27	100.0

Source: Field survey, 2016.

4.3.5.1 Marketing margins involving middlemen for Paddy Rice

According to Hussain et al., (2013) the percent marketing margin (MM) can be calculated as MM = Ps/Sp * 100……………………………………………………4.4

Where; MM = Marketing Margin

Ps[1] = Price spread, Sp = Sale price

Price spread = Sale price – Purchase price

Therefore, gross marketing margin between farm gate price and market price is calculated as

Ps = 93.65 – 83.00 = 10.65

Percent marketing margin = 10.65/93.65 * 100 = 11.37 percent

Transport (market) cost **(**GH¢/50kg**) =** 4.36

Net Profit **(**GH¢/50kg**) =** 10.65-4.36 = 6.29

Net Profit as percentage of margin = 6.29/10.65 = 59.06 percent

Net profit as a percentage of sale price (market price) = 6.29/93.65 * 100 = 6.71 percent

Table 12: Market margins[2] involving middlemen for paddy rice (GH¢/50kg)

Item	Average Farm gate Price	Average Market Price	Gross margin	Average Transport cost	Net profit Margin	Net profit as % of Sale price
Paddy rice	83.00	93.65	10.65	4.36	6.29	
Percent			**11.37**	40.93	59.06	6.71

Source: Field survey, 2016.

[1]. The difference between price (Sp) sold to final consumers and the price (Ps) received by farmers at farm gate by middlemen.

[2]. Marketing margin refers to the price movement along the rice supply chain.

4.3.6 Results of objective four

The input-oriented VRS model was used to estimate the efficiency of production technologies used in rice production. This is because, the use of production inputs (such as fertilizer, seed, herbicides etc.) are under the control of farmers and thus are the decision variables. The DEA results for study area (pooled) showed a mean overall technical efficiency (TE_{CRS}) of 0.44, pure technical efficiency (TE_{VRS}) of 0.64 and scale efficiency of 0.68 (see Table 13).

Table 13: Input-oriented VRS DEA model results

Efficiency	Mean efficiency score	Standard deviation	Minimum	Maximum
Overall TE ($_{CRS}$)	0.44	0.26	0.08	1.00
Pure TE ($_{VRS}$)	**0.64**	0.24	0.10	1.00
Scale efficiency	0.68	0.23	0.25	1.00

Source: Author's Computation, 2016.

A look at Table 14 also show that technically efficient farmers had farm sizes slightly lower than the average for the sampled farmers and also used lesser amount of productive resources compared to inefficient farmers.

Table 14: Comparison of average input use between efficient and inefficient farmers in northern region of Ghana

Average input use	Farm size (ha)	Seed (kg)	Fertilizer (kg)	Herbicides (litres)	Labour (qty)	Rice yield (kg/ha)
Inefficient Farmers	2.53	177.47	348.48	8.38	13.68	2,613.22
Efficient Farmers	1.68	82.50	248.81	5.67	10.52	3,371.43

Source: Author's computation, 2016. Note: efficient farmers used 164.29kg/ha of NPK (3.3 bags), and 84.52kg/ha of Urea (1.7 bags).

Table 15 indicate a one-way Analysis of Variance (ANOVA) of inputs use between efficient and inefficient farmers for the study area. It is observed that there is statistically significant difference between efficient and inefficient farmers in terms of inputs use, at 5 percent significant level or higher (Table 15).

Table 15: One-way ANOVA of input use between efficient and inefficient farmers in the study area.

Item	Farm size	Fertiliser	Seeds	Labour	Herbicides
Inefficient	2.915	443.859	417.632	15.684	9.456
Efficient	1.741	262.255	194.294	10.137	6.058
F-cal.	3.930	3.760	5.500	20.440	4.270
P-value	**0.049**	**0.050**	**0.021**	**0.000**	**0.041**

Source: Author's computation, 2016; (significant at 5 percent or higher)

For returns to scale, 90 rice farms recorded increasing returns to scale while a paltry (11 and 7) rice farms experienced constant returns to scale and decreasing returns to scale respectively as indicated in Table 16

Table 16: Summary of returns to scale and farm specific characteristics

RTS	No. of farms	Farm size (ha)	Average output (kg/ha)
CRS	11	2.73	6,054.55
DRS	7	4.29	7,078.57
IRS	**90**	2.16	2,032.97

Source: Author's computation, 2016.

4.3.6.1 Tobit regression analysis of the determinants of Technical efficiency

Onumah et al., (2013) posited that, the technical efficiency estimates under a given production unit are essential but not enough to merit policy interventions. As a result, there is the need to investigate the causes of the discrepancies in the technical efficiency estimates so as to design appropriate policies for the full attainment of the frontier output and this is done by specifying an inefficiency model. The Tobit model was employed to analyse the second stage regression analysis to determine causes of variations in the technical efficiency estimates under the DEA. The Tobit model was used because the efficiency scores are bounded between 1 and 0 as maximum and minimum values respectively. As a result, the technical efficiency estimates of each DMU were regressed on selected socio-economic variables by the maximum likelihood estimation to elucidate the drivers of technical inefficiency (Yong-bae and Choonjoo, 2010; Wouterse, 2008; Coelli et al., 2002). The result of the Tobit regression analysis showed a mixed technical efficiency results as presented in Table 5.4

4.3.6.2 Tests of research hypothesis

The null hypothesis that the socio-economic variables did not explain the presence of technical inefficiency among the rice farmers was rejected in this study (see Table 17).

Table 17: Test of hypothesis for the existence of inefficiency term

Null Hypothesis	Log Likelihood Function (H_0)	Test Statistic (λ)	Critical Value	Decision
H_0: $\beta_1 = \cdots = \beta_6 = 0$	-26.769	27.810	12.592 (6)	Reject H_0

Source: Author's self estimation, 2016. Critical values are at 5 percent significance level and obtained from χ^2 distribution table. Figure in bracket refers to the number of restrictions.

4.3.6.3 Results of the Tobit regression

It is observed from table 18 that, among the socio-economic variables believed to elucidate the technical inefficiencies of the rice farmers, farm size, family hands, and farmers' experience were the only variables which were statistically significant. However, experience and farm size both had a negative effect on farmers' efficiency. The coefficient of family hands is positively related to technical efficiency, suggesting that the larger the number of family hands on rice farms, the higher the technical efficiency. Also, its significance is highly plausible. We also observed that extension contact, education and access to agricultural mechanisation all had a positive effect on technical efficiency although they were not statistically significant. This might be due to the low extension-farmer contact, less number of years spent in education and inadequate access to agricultural mechanisation as we observed in the study.

However, the positive effects of these variables imply that an increase in these variables will in turn boost technical efficiency as farmers' knowledge and understanding about production techniques will be enhanced and also drudgery in agricultural operation will be decreased.

Table 18: Estimation results of the Tobit model

Variable	Parameter	Coefficients	Standard error	P-value
Constant	β_0	0.673	1.009	0.000
Farm size	β_1	-0.036	0.010	0.001
Agric. mech.	β_2	0.024	0.092	0.795
Family hands[3]	β_3	0.042	0.012	0.000
Extension contact	β_4	0.001	0.005	0.775
Experience	β_5	-0.014	0.004	0.001
Education	β_6	0.009	0.006	0.141

Source: Author's self estimation, Significant at 1% Pseudo R^2 = 0.3425

[3]. Family hands refers to the number of household members who work on the rice farm.

DISCUSSION

The study revealed that 54.3 percent of the respondents in the study area, had never been formally educated. However, 35.2 percent of the respondents with formal education attained basic education (primary and JHS level). This implies that only 45.4 percent of the respondents could neither read nor write (level of illiteracy). Human capital is a significant asset for agricultural development and therefore, education plays a key role in decision making and the ability to absorb modern agricultural technology and hence has a bearing on agricultural productivity (Asadullah et al., 2005; and Kibaara, 2005). Furthermore, education enables farmers to comprehend the social and economic factors governing their farming activities (Shamsudeen et al., 2011).

A little over sixty-three percent of the respondents were males as against their female counterparts of 36.1 percent. This suggests that less female farmers were engaged in rice production compared to their male counterparts. Perhaps rice production is a labour intensive activity and notwithstanding the numerous roles of women, more males are involved in rice production. This result is synonymous with findings of (Addison et al., 2014) who observed low number of females involved in rice cultivation.

Explicitly the research indicated that majority (90.7 percent) of the respondents used farm tractor for ploughing their rice plots. On the contrary, a handful (9.3) used animal power (bullock service) for ploughing their rice plots. This confirms the report of MoFA and SRID, (2013) that bullock farming is been practiced in the Northern region of Ghana.

Good seed is an indispensable ingredient in productive agriculture as it is the starting point for all crop cultivation. Mandii considered the local variety in the study area was mostly (18.5) cultivated by the smallholder rice farmers. According to Crops Research Institute (CRI) and Savannah Agricultural Research Institute (SARI) breeders, this variety is suitable for low-input systems, can endure long flood periods, and can contend well with weeds (Ragasa and Chapoto 2016). Subsequent to this, was Salmasaa one of the improved varieties with 17.6 percent followed by Jasmine 85 with 16.7 percent and the others in that order. According to the farmers, Jasmine 85 was mostly preferred by consumers as it was aromatic, early maturing and the highest yielding rice variety cultivated in the area.

Findings from the study revealed that, household labour was the chief source of labour for rice cultivation and when it was inadequate hired labour was sought. Baden et al., (1994) stated that smallholder farmers with holdings less than 1.6 hectares, employed some form of hired labour, emphasising the fact that resource-constrained farmers are still labour users.

The study indicated that majority (26.9 percent) of the respondents had access to and expended the farm tractor for ploughing and harrowing their farmlands. According to (Kibaara, 2005), production efficiency is enhanced through agricultural mechanisation of farm operations. Also, a baseline survey conducted by MoFA in 2005 revealed that about 40 percent of farmers in Ghana used some form of mechanisation. Further, the use of tractors in land preparation reduces technical inefficiency through timely land preparation and planting. Benin et al., (2011) stressed that agricultural mechanisation reduces drudgery and boredom associated with farming which in turn spearheads increased production, productivity and promote rural employment.

Agricultural advisory services are essential to improving crop productivity. More than half (58.3 percent) of the respondents benefited from agricultural extension service from government paid extension agents underscoring the role of Ministry of Food and Agriculture (MoFA) in extension delivery. Other sources of extension services accounted for about 13.9 percent. Al-hassan (2012) stressed that agricultural advisory services have a bearing on crop productivity in that farmers who come into contact with agricultural extension services acquaint themselves with improved techniques and are able to combine inputs efficiently.

The role of credit in agricultural production cannot be over emphasised as access to credit support and increase food production remains a major challenge to small-scale farmers. Soliciting the means to purchase inputs such as fertiliser, agrochemicals and hiring of machinery could be the foremost hurdle for a farmer seeking to scale up production. Iyanda et al., (2014) argued that in order to expend improved inputs and hence adopt novel technology, farmers require credit. Most often than not, formal financial institutions are unwilling to offer credit to poor-resourced farmers due to perceived risks and dearth of collateral security. A total of 70 respondents representing 64.8 percent did not have access to credit facilities to facilitate purchasing of improved inputs to maximise rice output as opposed to 35.2 percent who had access to credit facilities. To this end, most of the smallholder rice farmers had to borrow from relatives, friends, middlemen and traders as opposed to formal sources. This confirms the findings of Esteban and Diao (2011) that traders are usually an important source of agricultural credit in rural areas. They lend to households who need money to pay for inputs such as hired labour or fertiliser, prior to harvest in return for their produce (paddy rice). This system of credit repayment with traders was the case for farmers who borrowed from traders in this study.

The sole aim of the fertiliser subsidy programme introduced in July 2008 by the Ghana government sought to partly absorb the cost of fertiliser to assist farmers purchase chemical fertilisers to boost output levels (Banful, 2008). Fertiliser use in Ghana before the introduction of the subsidy was 8kg per hectare, one of the lowest rates in Sub-Saharan Africa (MoFA, 2007). The chunk (77.8 percent) of the respondents ascribed their decision to cultivate rice to the fertiliser subsidy as it reduced their cost of production. Conversely, 22.2 percent thought otherwise. These confirm the findings of Benin et al., (2013) four years after the inauguration of the fertiliser subsidy programme which indicated a tremendous rise in fertiliser use.

We observed that a high proportion (60.2 percent) of the respondents belonged to farmer associations as opposed to 39.8 percent. As a result, they derived economic resource benefits including group extension through liaising with extension agents, group labour and timely access to production inputs among others. This finding is consistent with that of Portes, (1998) as cited in Iyanda et al., (2014), that membership to associations (social capital possessors) benefit explicitly from economic resources like subsidised credit and protected market among others.

The mean age of the smallholder rice farmers was about 41 years. This shows that rice farming is mainly practiced by the middle-aged group and hence fell within the economically active age bracket as the national description includes people from 15 to

60 years of age. This finding coincides with that of Addison et al., (2014) who found rice farmers in a similar age bracket in the Ashanti region of Ghana.

The average farm size of 2.36 hectares (5.9 acres) recorded from the study was slightly higher than the 2 hectares reported in MoFA, (2013) which indicated that most rural farm households operate with quite smaller land holdings. However, it was similar to Nyanteng and Seini (2000) who stated that over 90 percent of the country's food production came from farm holdings of 3 hectares or less.

Further, the study found a higher mean household size of 9.5 compared with 5.8 obtained in the 2010 census by the Ghana statistical service for Northern region. The mean household size reported in this study was also more than twice the national average of 4.4 (GSS, 2012). Meanwhile, the mean household labour of 4.02 was equally less than the average household size recorded for this study. This implies that the proportion of household members who could offer farm labour was far less than the total household members. The disparity between household size and household labour has implications for farm labour especially in northern Ghana where household heads rely on their household to provide labour for almost all their crop production operations. This also implies that households had more dependents, at least 5 dependents per household in the study area.

The study recorded a mean farming experience of 10.78. This implies that, farmers within the study area are very experienced in rice farming when it comes to the technicalities of rice production concerning choosing the right technology, accessing the right information and applying them. Our finding is synonymous with Lapple, ((2010) who posited that increase in farming experience provides better knowledge about production environment which governs farming decisions. An akin study by Kibaara (2005) who used age as a proxy for experience attributed that even though farmers become more skilled as they grow older, the learning by doing effect is depreciated as farmers' approach middle age and their physical strength starts to decline.

Farmers in the study received a paltry (4.9 times) extension contact during the cropping season, the reason might be low extension farmer ratio in the study area. This practically has implication on farmers' acquaintances with modern production techniques and their implementation which eventually affect efficiency and productivity levels. This result is analogous to Kalirajan (1981) who stressed that agricultural extension agents' inadequate contact with farmers and farmers' misapprehensions of the farming technologies are the main determinants for the differences between the actual and maximum yields among farmers. Xu and Jeffrey (1998) posit that extension visits to farmers are essential for lessening farm-level inefficiencies.

The study showed that, the local rice production of which the Northern region of Ghana produces a significant proportion (37 percent) of the national basket was not competitive and hence did not have the comparative advantage compared to other global producers. The DRC ratio of 1.35 implied that domestic resources were not used efficiently. These results disagree with those of (Adjao, (2011; Minh et al., 2016). However, it is consistent with studies of (Maji, 1996; Raisunddin, 2004; Kikuchi et al., 2016).

Expansion of rice production has been of key interest to most importing countries around the globe in order to meet national demand and hence supply deficits. We observed from our study that 79.6 percent of the respondents had the possibility of expanding their rice fields while 20.4 percent thought otherwise. This finding is analogous with the studies of Addison et al., (2015) who reported that rice farmers in Ahafo Ano North district of Ghana, had increased rice yields and these were as a result of expanded areas of production. A focus group discussion with the rice farmers emphasised that, the prevailing price structure of paddy discourages most farm families from venturing into rice production and hence expanding their rice fields. They stressed that measures should be put in place to increase the prevailing rice price, in order to encourage rice cultivation in the area since 37 percent of the total domestic rice production in the country emanate from the Northern region (Ragasa et al., 2013). Explicitly the respondents attributed their motivation to expanding their rice fields mainly by having access to production inputs on credit, ability to access financial support, increase in rice yield, larger family size and most importantly having higher producer price.

Increasing the efficiency of agricultural markets is very essential so as to improve the welfare of the rural poor households since food prices are highly volatile (Mitchell, 2011). Findings from the study underscore that, market opportunities exist for small-scale rice producers in the study area considering the average yield of 2.8 tons/ha. However, a focus group discussion held with the rice farmers indicated that "in order to enhance market opportunities and thus create avenue for achieving food security, there is the need for an initiative where paddy will be purchased from rice producers at harvest so as to intervene in rice marketing considering the challenges of inaccessible road networks and hence high transportation cost". These outcomes are consistent with the studies of Totin et al., (2012). According to the authors, buying paddy rice from producers during harvest sought to increase rice output for the purpose of obtaining food security through re-distribution of purchased rice as seeds to farmers in areas where rice production is being newly promoted.

Also, the farmers went on to add that, "considering the nutritional content of the local rice compared to imported rice, if the quality level of the local rice is improved through better post harvest processing measures (handling, grading and milling facilities), the country would no longer have to import rice with the reasons of better quality and taste as preferred by most consumers." (Focus group discussion with rice producers, 2016). This is analogous to the findings of Diako et al., (2010) that due to the poor quality of locally cultivated rice arising from poor post harvest handling and unavailability, most consumers will still patronise imported rice instead of locally produced rice.

In addition, the study revealed that market intermediaries for instance middlemen along the rice supply chain accounted for a significant share (11.37 percent) of the marketing margin and this might have some consequences on rice producers' income. Our result is analogous to that found by Hussain et al., (2013) who investigated into the marketing margins in the supply chain of tobacco in Pakistan and discovered that tobacco farmers were exploited by market intermediaries due to high marketing margins.

The DEA results for study area (pooled) showed a mean overall technical efficiency (TE_{CRS}) score of 44 percent, pure technical efficiency (TE_{VRS}) of 64 percent and scale efficiency of 68 percent, these meant that, on the average rice farmers in the study area has the propensity of reducing their inputs use by 56 percent, 36 percent and 32 percent respectively to produce the same amount of paddy rice. These efficiency scores illustrate the best practice performance in other words efficient use of the available technology or resources. By reducing scale inefficiency, the farm households can increase their mean technical efficiency level from 44 percent to 64 percent. The mean pure technical efficiency (64 percent) for the pooled is higher than that of Al-hassan, (2012) 53 percent and 51percent for both non-irrigators and irrigators in the Upper East region of Ghana respectively. However, is lower than 81 percent found by Donkoh et al., (2012). The low level of technical efficiency among rice farmers suggest the presence of erratic shocks such as poor rainfall, pests and diseases, low extension contact, declining soil fertility and managerial inefficiency (Al-hassan, 2008).

Similarly, Yusuf and Malomo (2007), argued that a farmer's efficient use of available technology may be influenced by non physical inputs such as experience, information asymmetry among other socio-economic factors. However, our findings are in line with the observations of Seidu et al., (2004). In a similar study by Rahman (2003) as cited in Udayanganie et al., (2006), the author discovered that modern rice cultivation is characterised by high levels of inefficiency. The author further emphasised that the differences in efficiency is largely influenced by low soil fertility, experience, extension services among others.

Notably, efficient farmers used an average of 248.81kg of fertiliser (both NPK and Urea fertilisers), 177.47kg of rice seeds, 5.67 litres of herbicides and employed approximately 11 persons on a 1.68 hectare plot to produce a yield of 3,371.43kg/ha of rice. Conversely, for inefficient farmers to reach up to the production level of the efficient (reference) farmers, they would have to decrease farm size by 0.85 hectares, reduce fertiliser use by 99.67kg, seed use by 94.97kg, herbicides use by 2.71 litres and labour by 3 units in order to boost yield by 758.21kg/ha. Additionally, the result of the one-way ANOVA of input use between efficient and inefficient farmers proved a significant difference (p-value at 0.05 and 0.01) between these two groups of farmers. For instance, there was a significant difference (0.049) between efficient and inefficient farmers in terms of number of hectares cultivated. This signifies expansion of farm size among rice farmers should be scale efficient.

The scale efficiency recorded the highest efficiency estimate of 68 percent which implies little scope for improvement in farm size to increase efficiency. This emphasised that the causes of inefficiencies perhaps are as a result of diseconomies of scale or mismanagement of resources. As we observed, scale efficiency was relatively higher in this study, which indicated that inefficiencies resulted from improper input use. This can be visualised on the lower VRS technical efficiency scores compared to the scale efficiency scores (list of individual farmer technical efficiency scores see appendix). These findings attest those of (Rio and Shively, 2005; Ören & alemdar 2006; Yusuf and Malomo 2007; Tipi et al., 2010; Padilla-Fernandez and Peter 2012; Lira et al., 2014).

In terms of returns to scale, ninety (90) rice farms indicated increasing returns to scale, which imply that the bulk of the rice farms would improve their efficiency of resource use by increasing in size. It also means that a proportionate increase in the use of inputs would lead to a more than proportionate increase in output levels. This evidently implies small-scale rice producers should consider further expanding production because an increase in input triggers an output increase at a larger proportion.

Further, results of the Tobit regression identified family hands, farmers' experience and farm size as the main determinants of technical inefficiency among small-scale rice producers in the study region. However, farmers' experience and farm size had a negative effect on technical efficiency. This means that for instance as farmers gain more experience by aging the doing-by-effect diminishes and hence reduces their technical efficiency. This also means that farmers who had less years in rice cultivation were technically inefficient compared with farmers with many years of experience. Farm size was observed to have an inverse relationship with technical efficiency. This maybe argued that small farms use land more meticulously by putting productive resources to efficient use (inputs mobilisation and resource management) and hence make them more productive. These findings confirm similar studies done by (Squires & Tabor 1991; Tchale, 2009; Bhatt, 2014) however it contradicts the findings of (Kamruzzaman et al. 2006; Bozoğlu & Ceyhan 2007; Tipi et al., 2009).

Also, extension contact, access to agricultural mechanisation and education had affirmative effect on technical efficiency despite they were not statistically significant.

This has implication that, with increased level of farmers' educational status, higher extension contact and increased access to agricultural mechanisation, farmers' understanding about production technologies and drudgery in rice production could be improved and hence enhance their technical efficiency. These findings agree with the studies of (Kibaara 2005; Al-hassan, 2008, 2012; Shamsudeen et al., 2013).

6. CONCLUSION

The domestic resource cost ratio of 1.35 showed that local rice production in the study region was not competitive and hence did not have the comparative advantage compared to other global producers. It implied that domestic resources were not utilised efficiently. However, technically efficient farmers were found to be competitive with a DRC ratio of 0.91, which means that domestic resources were efficiently used. The possibility of expanding rice production in the area was manifested by majority (79.6 percent) of the smallholder rice farmers and the need for rice producers to seize the opportunity to increase acreage in order to enhance productivity and subsequently improve food security.

It was observed that market opportunities exist for rice farming households in the area considering the average yield of 2.8tons/ha. The study identified that, the share of the marketing margin along the rice supply chain at the farm gate and local market centres with the involvement of middlemen was 11.37 percent. As a result, the rice farmers diverted their paddy rice to the local market because middlemen either offered lower prices or delayed in payment for the purchased produced.

The non-parametric DEA for study area depicted inefficiency in rice production with a mean overall technical efficiency (TE_{CRS}) of 44 percent, pure technical efficiency (TE_{VRS}) of 64 percent and scale efficiency of 68 percent. The result further explained that rice farmers were inefficient with the potential of reducing inputs by 36 percent to produce the same amount of paddy rice.

Majority (90) rice farms recorded increasing returns to scale whereas 11 and 7 rice farms indicated decreasing and constant returns to scale respectively. The estimated results from the Tobit regression showed that farmers' experience, farm size and family hands were the significant determinants of the technical inefficiency among smallholder rice farmers in the study area. These suggested that technical inefficiencies might be reduced when rice farmers' meticulously use productive resources efficiently and less experienced farmers learn from experienced farmers through the formation of farmer groups and also make judicious use of family labour.

7. POLICY RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed.

The average yield of 2.8tons/ha attained by rice farmers in the study area is an indication of high market potential and opportunities which when harnessed effectively by the National Buffer Stock Company (NAFCO) could contribute to achieving food security in the area.

Prioritising provision of linkage roads in rural areas to tackle inaccessibility would improve rice marketing and enhance the expansion of rice distribution across the country to ensure food security.

Relevant state agencies should put measures in place to reduce the influence of market intermediaries to minimise marketing margins in order to increase smallholder rice farmers' income.

National policies should favour optimum allocation of productive resources by considering the drivers of competitiveness.

Furthermore, rice farmers should organise themselves into farmer groups in order for less experienced farmers to benefit from the accrued knowledge of experienced farmers, as farmers' experience had significant effect on technical efficiency.

Similarly, family hands recorded a significant effect on technical efficiency of rice farmers, therefore smallholder rice producers should make judicious use of household labour on the rice farms as opposed to hired labour.

Policy makers would need to focus more on farmers' training and extension programmes to reduce technical inefficiency in rice production.

Appropriate crop management practices for the area should be determined and provided to rice farmers efficiently to increase rice productivity.

7.1 RECOMMENDATIONS FOR FUTURE STUDIES

This study focused mainly on efficient use of domestic resources to ensure food security through a competitive production.

i. Further studies may examine competitiveness under irrigated, non-irrigated and combined schemes among rice farming households in the study area.

ii. There are four rice producing regions in Ghana. Studies in these other regions would serve to verify and improve the findings of this study.

iii. Studies on a much larger scale than the scope of this research, may involve measurements of production of other crops cultivated by the farmers and evaluating the effects of these on production efficiency and competitiveness of rice production in the Northern region of Ghana.

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APPENDICES

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Appendix 1: Questionnaire for rice farmers

*These questionnaires have been designed to execute a research purposely for academic work. The researcher is **Samuel Ahado** a student pursuing master's degree in International Development and Agricultural Economics at the Czech University of Life Sciences, Prague. The main objective of the research is to assess the competitiveness of local rice production and its contribution to food security in the Northern region of Ghana. All information provided will be used solely and exclusively for academic purpose and would be treated with the necessary confidentiality it deserves. Information provided would be used to make sound empirical analysis and also suggest policy recommendations that would help improve and sustain domestic rice production to enhance food security as well as farmer's socio-economic well being and standard of living in the region. The entire interview will take nearly one hour of your time and you are kindly requested to provide honest and genuine answers within your possible best.*

Section 1: Biodata of Farmer

1. Name of Interviewer …………………………………………………………

2. Name of Region...……………………………………………………….

3. Name of District ……………………………………………………………….

4. Name of Community…………………………………………………………

5. Name of Respondent/compound…………………………………………………….

6. Age of Respondent………………………

[1] Less than 20 years [2] 21-30 years [3] 31- 40 years

[4] 41-50 years [5] 51-60 years [6] 61+ years

7. Sex of Respondent [1] Male [2] Female

8. Religion. [1] Christianity [2] Moslem [3] Traditionalist

9. Marital Status [1] Married [2] Single [3] Divorced [4] Widowed

10. Educational Background [0] No Formal Education [6] Primary Education

[9] JHS [12] SHS/Technical/Vocational [15] Tertiary

11. Main occupation [1] Farming [2] Civil/Public Servant [3] Trading [4] Artisan [6] Student [7] Other (specify) ……………………..

12. Minor occupation ………………………………….

Section 2: Farming and Production System

13. How did you acquire your farm land? [1] Own/Family [2] Rent [3] Squatter

14. What is the size of your rice farm in acres/hectares? …………………………..

15. Number of years in rice cultivation…………………………

16. What other crops do you cultivate?

Crop	Acreage (ha)

17. What is your household (HH) size? …………………………

18. Number of HH members who work on the farm …………………………..

19. What varieties of rice do you cultivate?

a…………………………………… b ………………..............................

c…………………………………

20. What production system do you use in producing your rice? [1] Rain-fed agriculture [2] Irrigation system

21. What cropping system do you use in producing your rice?

[1] Mono cropping [2] Mixed cropping

22. How do you prepare your land for rice cultivation?

[1] Tractor Service [2] Bullock Service [3] Hoe/ Cutlass [4] Weedicides

[5] Other (specify)……………………………………..

23. What type of labour do you make use in the rice production process?

[1] Group Labour [2] Hired Labour [3] Family Labour [4] Self Only

24. How do you thresh your paddy rice please specify...

25. How do you dry your rice?..

26. How many years do you cultivate on piece of land before moving on to another?

....

27. Is there any possibility to increase your acreage? [1] Yes [2] No

i) If yes what motivate you to increase your acreage. ………………………………….

ii) What is the cost involved in expanding your acreage? ……………………………..

iii) If no possibility to expand rice farm why? ………………………………………….

28. Do you have any storage facility for your harvested crops? [1] Yes [2] No

(i) Do you have communal or cooperative form of storage in your area? [1] Yes [2] No

(ii) If yes which of the storage form do you belong to? [1] Communal storage [2] Cooperative storage

(iii) What type of storage facility do you have? [1] Traditional wood/thatch structure [2] Concrete structure [3] Metallic structure.

(Iv) If no storage facility why? [1] Expensive to construct [2] No surplus to store [3] Other (specifiy)…………………………………..

(v) Do you encounter any storage problems? [1]Yes (specify)……………………..… [2] No

(iv) If you face any storage problem specify how you control it ……………………………………………………………………

29. What are some of the diseases and pests that affect your rice on the farm? [a] Pest .... [b] Disease ....

30**. Section 3: Economics of Production**

Input	Quantity Used	Unit Cost GH¢	Total Cost GH¢
Local seeds (kg/ha)			
Improved/Certified seeds (kg/ha)			
Ploughing (per ha)			
Harrowing (per ha)			

Herbicides (litres/ha)			
Organic fertiliser			
Inorganic fertiliser NPK Urea			
Family Labour (person-day/ha)			
Hired Labour (person-day/ha)			
Planting			
Transport			
Harvesting			
Threshing			

31.Please, indicate the total number of bags of rice you harvested and the price per 50kg bag during the last farming season (2014/2015).

Rice plot	No. of bags	Price per bag GH¢		Total Revenue	
		Farm gate	Local market	Rev. farm gate	Rev. local market

Section 4: Technology and Financial Support

32. Have you had some training in rice production? [1] Yes [2] No

If yes, who gave you this training? ....

33. Would you like to receive training in rice production? [1] Yes [2] No

34. Would you be willing to pay for the training yourself? [1] Yes [2] No

35. Where do you receive extension service from? [1] MOFA [2] NGO……………….

[3] Other (specify)………………………….

36. How often do Extension Officers visit you?

[1] Once a week [2] Once a month [3] Other (specify)…………………….

37. Have you ever visited a demonstration /exhibition farm? [1] Yes [2] No

38. Do you belong to a farmer association? [1] Yes [2] No

39. What benefits do you derive from the group as a member?

……………………………………………………………………………………

....

40. Has the fertiliser subsidy programme informed your decision to cultivate rice?

[1] Yes [2] No

41. Do you have access to tractor services for farm operations such as ploughing, carrying farm produce, harvesting, threshing etc. (as proxy to level of agric. mechanisation)? [1] Yes [2] No

42. Please, indicate any credit source(s), amount, interest rate and payment schedule.

Credit source	Amount GH¢	Interest Rate	Payment schedule	Ability to repay

Section 5: Constraints and Challenges in rice farming during the cropping season

43. What are some of the constraints you faced on your rice farm during the cropping season?

Mention them ……………………………………………………………….

44. What are some of the main challenges you encountered as farmer during the last cropping season. Can you mention them……………………………………………

Section 6: Marketing of paddy rice by rice farmers in the area

45. How do you market your farm produce (rice) and other staples? [1] At farm gate [2] local market

46. What quantity of your proceeds do you consume? ………………….

47. Do you keep some of your rice as seeds for the next season? [1] Yes [2] No

48. Do you have ready market (demand) for your produce at the marketing centres than at farm gate?

49. What is the cost involved in transporting your rice to the marketing centres? ....

50. Do you have proper road network to transport your produce to the marketing centres? [1] Yes [2] No

51. What are some of your expectations from the government about your rice production? ……………………………………………..

Questions for focus group discussion

1.What do you think can be done to improve marketing of paddy rice and food security in the area?

…………………………………………………………………………………………….

…………………………………………………………………………………………….

2.What is the level of paddy rice patronage in the area by rural consumers?

……………………………………………………………………………………………

……………………………………………………………………………………………

3.Do you have any idea how rural consumers can be enticed to patronize local rice in the area?

……………………………………………………………………………………………

……………………………………………………………………………………………

4.Do you have any idea about the potential market opportunities this area has regarding the assorted imported rice in the markets?

……………………………………………………………………………………………

……………………………………………………………………………………………

5.How does the activities of middlemen influence your profit margin considering the different information regarding producer price in the area?

……………………………………………………………………………………………

Appendix 2: Questionnaires for middlemen

Section 1: Biodata of Middlemen

1. Name of district …………………………
2. Name of community ……………………
3. Name of middlemen ……………………
4. Age ………………
5. Sex of Respondent [1] Male [2] Female
6. Religion. [1] Christianity [2] Moslem [3] Traditionalist
7. Marital Status [1] Married [2] Single [3] Divorced [4] Widowed
8. Educational Background [0] No Formal Education [6] Primary Education

[9] JHS [12] SHS/Technical/Vocational [15] Tertiary

9. Minor occupation. ....

Section 2: Marketing relationship with paddy producers

10. What is the general attitude of rice producers to price changes in the area? ………………………..
11. Are the rice producers will to sell their rice to you at farm gate price? [1] Yes [2] No (i) If no why……………………………
12. How many middlepersons serve the area? …………………………
13. What is the quantity (in 50kg bags) of rice you normally purchase from the rice producers during the cropping season? ……………
14. Considering the transport and other cost involved in purchasing from the farm gate level, do you make considerable profit. Specify cost involved. [1] Profit [2] Loss
15. How does the national price of rice influence your profit level in the area? Specify please………………………………………………………………
16. What problems do you face with the rice farmers when purchasing paddy rice from them? ………………………………………………………………
17. Can you kindly estimate the national average price of paddy rice in the area?.......

THE END

THANK YOU FOR YOUR TIME, PATIENCE AND PARTICIPATION.

Appendix 3: FOB and CIF price of imported rice by Finatrade.

FOB AND CIF PRICES OF IMPORTED RICE BY FINATRADE COMPANY

Country	Rice type	FOB (US$/MT)	CIF (US$/MT)
Vietnam	White long grain 5% broken	428.00	524.30
	White long grain 100% broken	350.00	**428.75**[4]
	Jasmine 5% broken	595.00	728.88
Thailand	White rice 100% grade B	565.00	692.13
	White broken A.1	532.00	651.70
USA	White rice 5% broken	530.00	649.25
	White rice 10% broken	515.00	630.88

Source: Finatrade Ghana September, 2016.

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Appendix 4: Input-oriented VRS DEA Model results for the individual rice farmers in the sample

[4] The price in the bold colour was the CIF price used for the DRC ratio calculations in this study since the quality of locally produced rice in the country is very low.

Appendix 4: Input-oriented VRS DEA model results for the individual rice farmers

Input-oriented VRS DEA Model results for the individual rice farmers in the sample

DMUs	**OTE_{CRS}**	**PTE_{VRS}**	**Scale Efficiency**	**RTS**
1	0.224	0.805	0.279	Increasing
2	0.26	0.666	0.391	Increasing
3	0.107	0.375	0.284	Increasing
4	0.604	0.619	0.975	Increasing
5	0.275	0.726	0.379	Increasing
6	0.604	0.705	0.856	Decreasing
7	0.434	0.517	0.839	Decreasing
8	0.535	0.569	0.939	Increasing
9	0.112	0.267	0.418	Increasing
10	0.396	0.45	0.881	Increasing
11	0.232	0.34	0.681	Increasing
12	0.407	0.702	0.58	Increasing
13	0.65	1	0.65	Increasing
14	0.267	0.667	0.4	Increasing
15	0.37	0.44	0.839	Increasing
16	0.258	0.399	0.646	Increasing
17	0.573	0.673	0.852	Increasing
18	0.15	0.588	0.255	Increasing
19	0.388	0.592	0.654	Increasing
20	1	1	1	Constant
21	1	1	1	Constant
22	0.717	0.765	0.938	Increasing
23	0.375	0.562	0.668	Increasing
24	0.313	0.527	0.593	Increasing
25	0.309	0.611	0.506	Increasing
26	0.375	0.67	0.56	Increasing
27	0.081	0.102	0.802	Increasing

28	0.14	0.456	0.308	Increasing
29	0.652	1	0.652	Increasing
30	0.55	0.954	0.577	Increasing
31	0.2	0.52	0.385	Increasing
32	0.232	0.356	0.652	Increasing
33	0.395	0.425	0.929	Increasing
34	1	1	1	Constant
35	1	1	1	Constant
36	0.346	0.52	0.665	Increasing
37	0.2	0.681	0.294	Increasing
38	0.471	0.482	0.977	Increasing
39	0.332	0.361	0.919	Increasing
40	0.293	0.774	0.379	Increasing
41	0.362	1	0.362	Increasing
42	0.25	0.735	0.34	Increasing
43	0.185	0.423	0.437	Increasing
44	0.458	0.699	0.656	Increasing
45	1	1	1	Constant
46	1	1	1	Constant
47	0.603	0.664	0.908	Increasing
48	0.394	0.509	0.774	Increasing
49	0.236	0.5	0.471	Increasing
50	0.325	0.555	0.586	Increasing
51	0.275	0.462	0.595	Increasing
52	0.5	1	0.5	Increasing
53	0.35	1	0.35	Increasing
54	0.25	0.532	0.469	Increasing
55	0.15	0.34	0.442	Increasing
56	0.28	0.376	0.745	Increasing
57	0.3	0.557	0.539	Increasing
58	0.15	0.346	0.433	Increasing
59	0.25	0.508	0.492	Increasing

60	0.329	0.503	0.653	Increasing
61	0.471	1	0.471	Increasing
62	0.32	0.498	0.643	Increasing
63	0.714	0.877	0.814	Increasing
64	0.105	0.207	0.505	Increasing
65	0.3	0.568	0.529	Increasing
66	0.225	0.655	0.343	Increasing
67	0.25	1	0.25	Increasing
68	0.673	0.806	0.835	Increasing
69	0.55	1	0.55	Increasing
70	0.571	1	0.571	Increasing
71	0.288	0.521	0.553	Increasing
72	0.743	0.744	0.999	Decreasing
73	0.449	0.572	0.785	Increasing
74	0.286	0.655	0.436	Increasing
75	0.265	0.305	0.868	Increasing
76	0.638	0.643	0.992	Increasing
77	0.55	0.599	0.919	Increasing
78	0.206	0.481	0.427	Increasing
79	0.667	0.667	1	Constant
80	0.579	0.828	0.698	Decreasing
81	0.537	0.871	0.616	Increasing
82	1	1	1	Constant
83	0.342	0.467	0.733	Increasing
84	0.547	0.67	0.816	Increasing
85	1	1	1	Constant
86	0.135	0.34	0.397	Increasing
87	0.56	0.696	0.805	Increasing
88	0.289	0.583	0.496	Increasing
89	0.322	0.412	0.782	Increasing
90	0.237	0.354	0.67	Increasing
91	0.124	0.356	0.347	Increasing

92	0.191	0.256	0.746	Increasing
93	0.233	0.293	0.797	Increasing
94	0.30	0.355	0.845	Increasing
95	0.786	1	0.786	Increasing
96	0.46	0.615	0.748	Increasing
97	0.186	0.212	0.881	Increasing
98	0.815	0.832	0.979	Decreasing
99	1	1	1	Constant
100	1	1	1	Constant
101	0.679	0.763	0.891	Increasing
102	0.597	0.637	0.937	Increasing
103	0.867	0.873	0.993	Decreasing
104	0.17	0.573	0.297	Increasing
105	0.571	1	0.571	Increasing
106	0.826	0.84	0.983	Increasing
107	0.507	0.60	0.846	Decreasing
108	0.155	0.334	0.463	Increasing
Pooled	**0.44**	**0.64**	**0.68**	

Appendix 5: Estimated result of the Tobit regression model for the inefficiency term

Tobit TE FARMSIZE EXPERIENCE FAMILYHANDS EDUCATION EXTCONTACT MECH, ll ul

Tobit regression **Number of obs. = 108**

LR chi2(6) = 27.81

Prob. > chi2 = 0.0001

Log likelihood = -26.768871 **Pseudo R2 = 0.3419**

TE	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
FARMSIZE	-.0364875	.0103248	-3.53	0.001	-.0569668	-.0160082
EXPERIENCE	-.014264	.0042795	-3.33	0.001	-.0227523	-.0057757
FAMILYHANDS	.0421524	.0116176	3.63	0.000	.0191089	.0651959
EDUCATION	.0088767	.0059853	1.48	0.141	-.0029951	.0207484
EXTCONTACT[5]	.0014232	.0049579	0.29	0.775	-.0084107	.0112571
AGRIC. MECH.	.0239424	.0917279	0.26	0.795	-.1579994	.2058843
_cons	.6732574	.1009383	6.67	0.000	.4730467	.8734681
/sigma	**.2552642**	**.0205613**			**.2144809**	**.2960475**

Obs. summary: 1 left-censored observation at TE<=.101532

86 uncensored observations

21 right-censored observations at TE>=1

[5] EXTCONTACT refers to extension contact.

Appendix 6: A snapshot depicting questionnaire administration between researcher and respondents as well as means of transport to wards in the study area