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RICE COMMERCIALIZATION AND RURAL HOUSEHOLD WELFARE IN NORTHERN GHANA

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RICE COMMERCIALIZATION AND RURAL HOUSEHOLD WELFARE IN NORTHERN GHANA

BY

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DECLARATION

I, the undersigned hereby declare that this thesis entitled "**RICE COMMERCIALIZATION AND RURAL HOUSEHOLD WELFARE IN NORTHERN GHANA**" is the result of my own original work which has not been submitted for another degree in this University or elsewhere.

SEIDU BARNABAS KADIRI 24/02/25

(Student's Name) **(Signature)** **(Date)**

Supervisor

I, hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidance on supervision of thesis laid down by the University for Development Studies.

Prof. Awal Abdul-Rahaman 24/02/2025

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ABSTRACT

In the Northern region of Ghana, despite significant rice production, rice commercialization lags behind rice imports. Smallholder farmers, with potential for commercial-scale production primarily operate at subsistence levels. This study surveyed 420 rice-producing households, utilizing descriptive statistics to outline variables and exploring the role of agricultural support services in crop commercialization. The Binary Probit model identified determinants, while the endogenous switching regression model assessed its impact on per capita consumption expenditure. Propensity Score Matching (PSM) technique evaluated effects on household income. Findings reveal strategic allocation of 66% of rice production for sales, with factors such as age, farm size, and other non-agricultural factors influencing commercialization. Commercializing households show higher per capita consumption expenditure with an income distribution concentrated in the GHS 1001–GHS5000 range. Propensity score matching indicates a substantial (36.1%) income increase associated with rice commercialization. Non-farm income, remittances, agricultural training, and improved seeds play crucial roles. The study provides comprehensive insights, guiding efforts to enhance sustainable agricultural growth and economic well-being for smallholder farmers in Northern Ghana. Government policies in Northern Ghana should prioritize improving farmers' access to quality seeds and extension services, particularly through initiatives like the Planting for Food and Jobs program. Essential investments in rural infrastructure are crucial for reducing market access challenges and promoting smallholder engagement in commercial agriculture. To enhance market opportunities, policies should focus on strengthening linkages, implementing value addition initiatives, and exploring private sector partnerships to boost competitiveness and income from locally produced rice. Future research should consider comprehensive longitudinal studies to assess the sustained impact of rice commercialization on household income and economic well-being in the region.

DEDICATION

I dedicate this thesis to the unwavering support and boundless love of my family. Their encouragement, understanding, and sacrifices have been my pillars of strength throughout this academic journey. Their belief in my abilities and the countless moments of inspiration you provided have fueled my determination to reach this milestone.

I extend my deepest gratitude to my thesis supervisor for his guidance, expertise, invaluable mentorship and the patience he has had for me during this thesis period. His insightful feedback, constructive criticism, and unwavering commitment to excellence have shaped this thesis and my academic growth. I am fortunate to have had the opportunity to learn under his tutelage.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The agriculture sector has been noted to be a major driver of growth and development of most developing countries of the world (World Bank Group, 2018). The role of agriculture as a source of employment of the developing countries cannot be overemphasized. In view of this, studies (Smith, 2008; Kirui & Njiraini, 2013) suggest that, the supply of food should be sustainably increased in order to meet the high rate of population growth particularly in the developing world. Agriculture does account for a large fraction of the economic activities of countries that is measured in absolute terms and in the sub-Saharan Africa region, many countries have at least 30% or more of their GDP accrued from the agriculture sector and in some other few countries, the share from the agriculture sector is nearly 50% (Gollin, 2009). The consumption of rice has assumed an escalating trend globally. This has translated into the Sub-Saharan region of Africa in which the importance of rice is rapidly growing (Kijima et al., 2013).

Rice is the second most cultivated cereal in the world and it is a very important food crop for about half of the world's population (Seck et al., 2012). Thailand, China, India and Japan produce large quantities of rice at comparatively low cost to developing countries. A large percentage of the rice that is imported to developing countries come from the aforementioned countries and are of better quality (Bandumula, 2018). As a result of the low production cost of rice in these countries, commercialization is very competitive. The commercialization of rice in countries specifically the developing countries has been tied to the cost of production, the level of production, the availability of inputs for the production among other factors.

The agriculture sector plays the role as a major employer of the rural populace in developing countries such as Ghana (World Bank Group, 2018). The production of rice is very common to the rural population especially in the developing countries and these rural folks also depend on the production as their source of livelihoods as they commercialize the rice that is produced. These rural folks are mostly smallholder farmers who make up the majority of rural farmers in the world. Abdullah et al. (2019) reports that there are about 500 million smallholder farms in the world and about 2 million people have their dependence on these smallholder farms as their source of livelihoods. In excess of 80% of food produced in the Sub Saharan and the Asian Regions of the world emanate from smallholder farms and most these smallholder farmers focus on subsistence levels with the aim of self-consumption with some of them who are bent on maximizing welfare by commercializing some of the produce that come from the smallholder farms (Abdullah et al., 2019). The transition from subsistence or semi-subsistence farming to commercial production is a key feature in the development of low-income countries. Commercialization enhances efficiency and trade, leading to economic growth and improved welfare at the national level (Carletto et al., 2017).

Commercialization of rice by producers have been observed to have some influence on the welfare of the smallholder farmers who do the production. Commercialization therefore enhances advanced systems of production which emanates as a result of the comparative advantage of the smallholder farmers and these translates into innovative ways of production and hence having the gains of welfare on the smallholder farmers (Abdullah et al., 2019). The welfare of smallholder farmers is based on the recognition of their role as a key driver in poverty alleviation and sustainable growth. (Muriithi & Matz, 2014). Poverty alleviation and the

sustainability of the smallholder farmer is the major determinant of the welfare of the farmer. Welfare improvement of smallholder rice farmers depend largely on the ability of the farmer to afford the requisite inputs and other support services which goes a long way in translating to the increased productivity and growth (Awotide et al., 2016).

According to Jaleta et al. (2009), the commercialization done by smallholder farmers can enhance household welfare, via the patronage of foods that have high values, better education for their children, ability to meet basic needs among many others. Commercialization does impact on different socioeconomic groups such as the rich, the poor, the owners of the land, landless farmers, women, and children in different ways (Abdullah et al., 2019).

The new developments in the global environment which is characterised by high growth rate of population, the rise in income, urbanization, policy reforms, technology, global interconnectedness, food industry restructuring and climate change calls for the transformation of agriculture. Commercialization can aid this by changing the current production practices from highly subsistence level towards highly market-oriented level. (Barrett et al., 2012).

The consumption of rice in Ghana has grown substantially at an average of 12% per annum in Ghana (Barrett, 2010). The main drivers of the consumption of rice in Ghana include population growth, higher growth rate, urbanization and the changing pattern of consumption in the country (Kwasi, 2015). The domestic market for rice in Ghana has been expanding over the years in spite of the fact that the estimations of the expansions vary and the main issue is that, about two thirds of rice consumed in Ghana is imported. In the production of rice, Northern Ghana has a comparative

advantage over southern Ghana as it has about 70% of the total area for the production of rice in Ghana (Ragasa et al., 2013).

The commercialization of rice in Northern region is highly dependent on the cost of production, the yield and the availability of inputs for the production process. Agricultural support services including agricultural extension according to Ferris et al. (2014) are being developed in order to connect small-scale farm workers with modern farming methods, and institutional structures such as agricultural marketing, services cooperatives. In Northern region, the production of rice uses large labour quantities for the rice value chain such as planting, weeding, harvesting, processing and marketing (Tanko et al., 2016). This is the part of the country that cultivation of domestic rice is done under three main systems which includes rain fed upland, rain fed lowland and irrigated rice farming systems. The rain fed lowland production dominates the rice production systems in Northern Ghana followed by irrigated systems and Rain fed upland systems. There are various factors that influence the marketing of rice in Northern region which include the yield of the rice on annual basis, the cost of production which includes the input costs, transportation, and the climatic conditions among various factors.

Post-harvest pricing of rice in the Northern region does suggest that rice production is driven by entrepreneurs who are motivated by the profits from their investments. In the quest of farm households in the Northern region to make maximum returns on their rice, there is the need for them to consider the most favourable place, time and the form in which their products can be marketed (Taiwo & Bart-Plange, 2016). In this regard, the prices or the market of rice in Northern region differ between time periods, the quality of the product and between alternative markets for the products.

Rice commercialization in Northern region is done in both formal and informal places. Formal markets are made up of designated places managed by public institutions whiles the informal markets are not recognized formally. This includes a group of people who buy from farm roads or people who meet regularly in the villages to buy from farmers. In Ghana, rice producers organize themselves into commodity-based associations to enhance better conditions of market for their produce.

1.2 Problem Statement

Research has supported the notion that in order to increase rice productivity, enhance poverty reduction and improve the welfare of the rice producing households, there is the need to adopt the right inputs, support services and make a commercialization drive out of the production (Bello et al., 2021; Awotide et al., 2012). In view of this, the welfare of the smallholder farmer is dependent on the commercialization drive of the farmers after harvest. This is because, as the food crop is cultivated for subsistence, there is no income accrued to the crop and as there is no income, the farmer's ability to meet needs which involve the use of income tend to be compromised.

The farming systems in Ghana have now been characterised by the adoption of improved technology in order to increase and boost the level of productivity. These include the adoption of modern technologies, the use of improved varieties, access to support and extension services among many others. In spite of the advancement in modern technology and the adoption of improved varieties of rice, farmers still suffer from low levels of income and poverty which translates into poor living conditions.

According to the World Bank Group (2018), the poverty levels of rice producing households can be reduced and the welfare of these farmers can be improved if they effectively participate in the output market. Commercialization therefore holds the future to a sustained increase in agricultural productivity and profitability for the rice producing households. According to Jayne et al. (2018), commercialization is a very strong tool that could be used to increase the income of rural households and ensure welfare.

Commercialization of rice among Ghana farmers has developed remarkably in recent years, though challenges persist. In 2020, the self-sufficiency ratio of rice in Ghana was about 43%, indicating that the country relies on imports to meet the domestic demand (MoFA, 2022). Most farmers in Ghana producing rice are smallholders, cultivating less than two hectares of land with limited accessibility to improved inputs (Tsinigo & Behrman, 2017)

There have been various policies in Ghana that is targeted at commercialization of agricultural products and notable among these policies is the policy document on Food and Agricultural Sector Development Policy (FASDEP) I and II and the "Planting for Food and Jobs" which is mainly targeted at the commercialization of agriculture in order to increase productivity. In the policy documents, there has been increasing importance given to the production of rice as rice plays a very important role in improving household income and enhancing food security (MoFA, 2022). Food security and household income can be enhanced effectively through commercialization as commercialization is a mechanism that enhances the reduction in the risks that is associated with the production of rice (Jayne et al., 2019)

Commercialization of agricultural products have gained the attention of the Ghana government and other international development partners since they seek to increase the business aspects of crop production, these agencies undertake interventions to improve the production through building smallholder farmer capacity. The planting for Food and Jobs programme which has been rolled out by the Ghana government is a major policy that is aimed at increasing crop production and commercialization. In the rice sector, several non-governmental organizations such as the Japanese International Cooperation Agency (JICA), the USAID Funded Resiliency in Northern Ghana (RING), CSIR-Savannah Agricultural Research Institute, Association of Church based Development Projects (ACDEP), Regional Advisory Information and Network Systems (RAINS) among others have over the years championed the production and the commercialization of rice in Northern Ghana.

Despite governmental and non-governmental interventions in the commercialization of rice in the country, there is still a gap between the domestic demand and the domestic supply of locally produced rice as currently in the Ghanaian market, only 43% of locally produced rice meets the demands of the urban market and with the imposition of 20% import duty on imported rice, it still surpasses that of the rice (MoFA, 2022) . The Ghanaian agricultural sector is one sector that is led by smallholder farmers. This is partly as a result of the fact that the country is dominated by rural areas and these areas make up lots of the smallholder farmers.

In Northern Ghana, in spite of the premise that it is the hub for rice production, its commercialization still falls lower than that of imported rice. This is partly as a result of the smallholder farmers in the Northern part of the country still producing the rice at subsistence level despite having the opportunities to produce in commercial

quantities. This study is specifically based on farm households that undertake rain-fed production. This is because Ghana's agricultural sector is highly dependent on rainfall for production as very limited land is being employed for irrigation farming in the country (Martey et al., 2012). Few studies (Donkoh, 2020: Ammo, Aidoo, Osei Mensah, Adzawla, Appiah-Twumasi, Akey, E. A.& Bannor, 2022: Azumah, Donkoh & Awuni, 2019) have been specifically done to explore the impact of commercialization on the welfare of the rice producing households in order to ascertain the reasons for commercialization and the reasons for the non-commercialization of rice produce. Most of these studies are focused on productivity, market participation and policy interventions without assessment of broader welfare outcomes in terms of income levels, Consumption expenditure and livelihood sustainability. Furthermore, though commercialization drivers and barriers have been explored, specific reasons for participation or non-participation are underexamined. It is therefore against this background that the current thesis seeks to examine the rice commercialization and rural household welfare in Northern Ghana.

1.3 Research Questions

The main research questions the study seeks to answer is "What is the effect of rice commercialization on rural household welfare in Northern Ghana?"

In order to achieve the research objectives, the following research questions are formulated to that effect and they are as follows

i. What are the determinants of rice commercialization in Northern Ghana?
ii. How does rice commercialization impact per capita household consumption expenditure in Northern Ghana?

iii. How does rice commercialization impact on household income in Northern Ghana?

iv. What role does agricultural support services play on rice commercialization in northern Ghana?

1.4 Objectives of the Study

1.4.1 Main Research Objective

The study is aimed at examining rice commercialization and rural household welfare in Northern Ghana.

1.4.2 Specific Research Objectives

The following are the specific objectives of the study

i. To examine the determinants of rice commercialization in Northern Ghana.

ii. To assess the impact of rice commercialization on per capita household consumption expenditure in Northern Ghana.

iii. To assess the impact of rice commercialization on household income in Northern Ghana

iv. To explore the role of agricultural support services on rice commercialization in northern Ghana.

1.5 Justification of the Study

The commercialization of agriculture has been observed to be an avenue through which household poverty can be reduced and the level of agricultural commercialization can inform policy makers on making appropriate policies in the agriculture sector. This study will therefore add new knowledge on commercialization and welfare in the crops sub sector. In practice, the study will feed into the design of policies on how to address challenges of low

commercialization of agricultural produce by smallholder farmers for growth and development of the agriculture sector. The study estimates commercialization and employs the results to estimate the role of commercialization on the income of the household and the per capita household consumption. Having an understanding of the impact of commercialization on household welfare will boost the commercialization drive specifically among smallholder farmers in northern Ghana.

The study offers a valuable opportunity for research organizations and relevant stakeholders to identify factors influencing commercialization of agricultural produce. Moreover, by assessing the support services on crop commercialization in Northern Ghana, stakeholders will be able to know how their current efforts have gone in enhancing commercialization of crops and what the gaps are.

The findings of this study will thus be relevant for the agriculture sector and interrelated bodies to understand rice commercialization and rural household welfare on the farm households and also inform further strategies. This will help inform a broader policy promoting the commercialization in the agriculture sector. To the academia, the findings from this study will help provide additional literature on rice commercialization and rural household welfare and also inform further studies into this subject matter.

1.6 Structure of the Thesis

This thesis contains five (5) chapters. Chapter one gives an introduction to the study and is set out in subsections. The Background of the Study introduces the level and nature of rice production from the global perspective to the Ghanaian perspective. The background also assesses the disparities in the production and the commercialization of rice in both developed and developing countries. The

commercialization of rice has also been highlighted and the ways through which smallholder farmers achieve their welfare was also captured on the background. The Research Problem statement looks at the challenges confronting smallholder rice farmers in the country. The measures set up to improve the welfare of commercialization of rice producing households in the Northern region and how these measures are not enough in addressing the welfare needs of the smallholder rice farmers in the country. In view of this, the research objectives arise from questions that were asked based on the research problem. The final section presents the justification for the study. In the Chapter two of the study, a review of literature surrounding the tenets of the study is undertaken in various subsections. The chapter further presents the empirical literature of the study.

The Methodology and Research Design is presented in various subsections in Chapter Three. Information on the study area, sources and types of data employed, the sampling method and sample size determination procedure, and the data collection tools and methods are outlined in this chapter. Chapter four (4) which is the results and discussion presents the results of the data analysis as per the objectives of the study. The various objectives were addressed through the results obtained from the data that was collected. Chapter five (5) summarizes the main findings of the study and conclusions drawn from them. The conclusions of the study are done as per the findings that were revealed from the data collected for the purpose of the study. This chapter also provides recommendations for policy decision and future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, relevant theoretical and empirical literature is reviewed. The relevant literature that is appropriate for the study and conforms to the objectives of the study is reviewed in this chapter.

2.2 Definition of Concepts

2.2.1 Commercialization

Agricultural marketing is not the same as agricultural commercialization. Agricultural commercialization occurs when household's product decision and input usage choices are made with maximising profit in mind (Minot et al.,2021). Agricultural commercialization is the production of crops for sale in the market instead for the purpose of consumption (Minot et al., 2022). In practical terms, commercialization is the process in which the farmers establish more links between the input and output markets as they drift from subsistent systems of farming to more specialized systems of crop production (Yaseen et al., 2018). Rohana (2010) expanded the definition of agricultural commercialization as the selling of surplus produce from the farm production which is marketable. In this view, any other produce from the production which is not marketable cannot be referred as the commercialization of that produce. When it comes to agricultural output, commercialization is assessed as a ratio of the value of agricultural sales compared to the value of agricultural production, while it is calculated as a ratio between the market inputs and the value of agricultural production when it comes to agriculture inputs (Leavy & Poulton, 2007). On the technical side, agricultural commercialization is a move from subsistence agriculture to a more complicated

market-based production and consumption system, which strengthens the links between input and output sides of a market (Gebremedhin, 2010)

Commercialization of agricultural commodities has been further defined by Gebremedhin (2010) as the act and process of increasing from the production realized, the proportion of that production that is sold by the farmers. This definition of commercialization is based on the volume of the produce that is sold by the farmer and from his view, commercialization goes beyond selling proportions of the farm produce to increasing the proportion of the farm produce that is produced by the farmer. Commercialization is therefore a decision that is made by the farm household as to the quantity of the produce to sell and that not to sell. Commercialization therefore integrates the farm households into both the domestic and the output market as they can get the opportunity to participate in the market in order to gain revenue from their production. In view of this, agricultural commercialization as put forward by authors (Osmani & Hossain, 2015; Omiti et al., 2009) can be well defined as the proportion of farm output that is put up for sale in the market and the ability of the farmers to increase their share of the market by raising the proportion of produce sold from the actual production.

Smallholder commercialization is a component of an agriculture process of transformation in which small farms transition from largely subsistence-oriented production to more specialized production that targets markets for both input sourcing and output supply (Minot et al.,2022). In a wider sense, smallholder commercialization might be viewed as a path to the total economy's structural transformation, in which non-agricultural industries create greater shares of economic production and employment. To achieve this critical aim of structural

change through a smooth process of smallholder agricultural commercialization, policy and strategic interventions to improve the functioning of input and output marketing, improvements in service provision, and infrastructure development stand out.

2.2.2 Welfare

Household welfare is seen by Yusuf (2008) as the control of the household over market and household goods and services. Welfare is a term that has had different definitions and views from different authors. Deacon (2002) looked at welfare as initially encompassing the supply of food but later emerged to be a term that represent the state of prosperity and happiness. Welfare is defined from several angles emanating from the social to economic perspectives. In the social perspective, welfare is defined as the provision of social services and the citizen support for individuals who lack the means to meet their basic needs (Therborn, 2020). In a country such as Ghana, the welfare of the citizens is mostly met through government tax revenue and other donor support through charity activities (Tijani, 2022). The governments further enhance welfare through developmental projects including the provision of portable drinking water, the provision of electricity, and shelter among many others.

Greve (2008) looked at welfare to encompass the ability of man to earn money and obtain material wellbeing. Robbins (2007) however criticized the definition by including the non-material aspect of welfare that includes the services of teachers, doctors among others which are also variables that promotes the welfare of man. Farmer welfare is the focal point of this study and it is defined as a condition of fundamental well-being in which an agricultural household, helped by its own farm

and non-farm earnings, as well as social security support, is able to meet the economic, social, and psychological requirements of all its members, in addition to their own investments necessary for long-term agriculture operations (Sugiana et al., 2018). Farmers' welfare is said to be achieved when a farm household is able to produce sufficient, reliable, and sustainable incomes from farm and non-farm industries that is not only adequate to fulfil the various needs connected with social dignity, but also leaves with savings that can be invested back into farming.

2.2.3 Farm Households

Farm households are the households that are adapted for the purpose of the study. The farm households are one or more individuals who live together and share a common livelihood and in this regard the livelihood is the operation of farm activities (Kehinde et al.,2021). Farm households live together and their main economic activity is farming. A farm household can be further viewed as a household in which at least one member of the household operates a farm activity.

The member of the household can be the household head, the reference person or the main earner of income in the household. According to Stifel (2010), farm households refer to a household in which the head of that household manages a farm or the main economic activity of the head is farming activities. In this regard, if the head of the household does not primarily engage in farming as an economic activity, then the household cannot be classified as a farm household. In Ghana, most of the farm households live in the rural areas with a small minority of farm households living in the urban areas and the Ministry of Food and Agriculture does define farm households as households that have their primary occupation and economic activity to be farming (MoFa, 2016). This is irrespective of the fact that the household head

is into farming or not as all other members of the household will assert that the household head presides over all activities of the house and if farming is the main occupation and income generating activity of the household, then that household will be referred to as a farm household. This is the generally used definition of farm households.

2.3 Commercialization and Welfare

Agricultural commercialization provides comparative advantages over subsistence cultivation in terms of revenue generation for smallholder farmers. The transition from subsistence to market economy (commercialization) may greatly boost the income and wellbeing of smallholder farmers while also contributing to economic growth and poverty alleviation (Zhou et al., 2013). Commercialization of smallholder crop producers through full involvement in output markets has been known as one of the best strategies to address low agricultural productivity, which has resulted in high levels of poverty and food insecurity among developing-country rural farming households (Jaleta et al., 2009). Smallholder commercialization allows developing nations with substantial agricultural population shares to create more money, resulting in economic growth. Increasing agricultural revenue increases demand for manufactured goods and services in other areas of the economy, driving further expansion. Commercialization of smallholder agriculture requires making decision based on market signals and participating actively in input and output markets. As a result, analysing the commercial transition necessitates an examination of market orientation and market involvement. Economic, institutional, and technology measures based only on market participation analyses may be insufficient if the causes of market orientation and additional markets are not the same (Gebremedhin, 2010).

Commercialization of smallholder agriculture is not just a way to increase exports or stimulate local economies; it is also a means of assisting smallholders in achieving welfare goals that can enhance their living situations (Gebreselassie, 2008). Agricultural commercialization provides benefits over subsistence farming in terms of revenue generation for smallholder farmers (Fan et al., 2013).The commercialization of subsistence agriculture may greatly boost the income and wellbeing of smallholder farmers while also contributing to economic growth and poverty reduction (Zhou et al., 2013). The commercialization of agricultural produce is very important as the welfare of the crop producing household is equally important. Commercialization of agricultural produce has been observed to be an effective means through which the issues of poverty can be addressed in the developing world though some studies (Jaleta et al., 2009). Kalkuhl et al. (2016) suggest that the switch from subsistence to commercial agriculture in an imperfect market can have substantial negative impacts on the welfare of the household as this can bring about volatility in the prices thereby exposing the household to food insecurity.

Literature divides the effects of agricultural commercialization into three categories: first, second, and third order effects. The first level effects are immediate household direct effects on income and employment, whereas the second order effects are healthcare and nutrition. These second-order consequences are mostly determined by the degree of money generated by the current level of commercialization. Finally, third-order consequences are macroeconomic and environmental effects that often extend beyond the household level (Muricho, 2015). These effects can be favourable or negative, with positive effects often outweighing negative repercussions. Commercial agriculture will also entail the establishment of a link between input

and output sides of markets. Greater usage of modern production inputs is believed to lead to increased output above subsistence needs, resulting in market surpluses. According to Linderhof et al. (2019), gains from agricultural commercialization can occur at both the household and regional levels via spill-over effects. They stated that commercialized output can alleviate the finance constraints that smallholder farmers often experience.

Commercialization is supposed to yield welfare increase at both the household and aggregate levels, according to theory. Fixed benefits could result from the fixed welfare effects of specialization and trade based on comparative advantage. They translate into income and employment impacts that are immediately reflected in household welfare, as well as improvements in health and nutrition that are dependent on income level. Dynamic benefits, on the other hand, result from higher production as a result of technical advances facilitated by increased technologies and exchange of ideas (Barrett, 2010). In Ghana, the majority of farmers are comparatively small producers, with subsistence agriculture providing a living for more than 70% of the population (Gali, 2023).

The majority of Ghana's population lives in rural areas, and smallholder farming businesses thrive there. Agriculture is the backbone of the rural economy, providing a primary source of food and revenue. Smallholder farmers' increased productivity can help decrease poverty, lower food costs, and enhance food security and increased income levels through commercialization among individuals (Osmani & Hossain, 2015). According to Zhang et al. (2021), market access and transitioning from subsistence to market-oriented agriculture can cause changes in economic growth and eventually, higher living standards. According to Christiaensen et al.

(2011), the good image of agricultural production as a means of reducing poverty inspires hope that smallholder farming will focus on improving farmer welfare, hence governments are promoting value added productions to agricultural products as a way to improve farm output and ultimately the value of the final product, particularly agricultural products. Studies (Martey, 2014; Awotide et al., 2016) have indicated that the commercialization of smallholder agriculture is primarily motivated by its ability to boost rural household economic growth; it increases the welfare of the majority of households, both directly via income impacts and indirectly through connections. Both forward back linkages are created by increased demand for farm inputs and the utilization of farmers' increased revenues to purchase consumer products.

Commercialization is recognized to offer comparative advantages above subsistence farming; it creates wealth and income for rural households and expands the use of hired labor beyond what was possible in subsistence farming (Fan et al., 2013). Higher income and employment as a result of commercialization result in a wide range of development in the rural economy as a whole (Haggblade et al., 2010). In order to improve welfare, access to the market of staple foods and wealth accumulation are encouraged. Smallholder farmers' welfare standards can increase if they have greater access to markets, better infrastructure, strong farmer associations, and the encouragement of contract farming. While some studies (Zhou et al., 2013) suggest the shift to commercial agriculture from subsistence agriculture boosts income, welfare and economic prosperity, others suggest that overproduced agriculture has had negative consequences, primarily by subjecting households to volatile food price levels (Osmani & Hossain, 2015)

2.4 Determinants of Commercialization

The misunderstanding of commercialization might lead to its misinterpretations which can hinder the implementation of policy. As a result of greater market excess, commercialization can occur either on the output or input side (Leavy & Poulton, 2007). As suggested by Jaleta et al. (2009), there are two ways to look at agricultural commercialization: an increase in the percentage of marketed output or an increase in the share of purchased inputs per unit production. Current research however focuses on the output side commercialization which is an increase in the percentage of marketed output. According to studies (Chapoto et al., 2013), agricultural commercialization is influenced by a number of factors. Depending on their duration, these characteristics might either help or hinder the commercialization process.

Population growth and rural infrastructural development according to Barrett (2010) are examples of long-term factors that affect commercialization. Barrett (2010) found that rural infrastructure had an influence on agricultural commercialization via its effect on pricing, dissemination of technology, and optimal integration of inputs and outputs. Studies has shown how improved technologies such as irrigation, improved varieties and fertilizer are used more when infrastructure is developed (Okello et al., 2012). When it comes to fertilizer use among farmers, pricing and distances to paved roads (an indicator of travel expenses) has a substantial impact. According to Ogutu & Qaim (2019) household's choice to commercialize is determined by the total of demographic, consumption and income-related factors. Commercialization will be lower in households where food production does not satisfy their consumption needs (Radchenko & Corral, 2018), but profits from selling produce can be used to help

pay for inputs, leading to improved productivity, which in turn improves commercialization (Radchenko & Corral,2018). Several studies have suggested that commercialization determinants (Jaleta et al., 2009; Gabre-Madhin, 2001; Martey, 2014 ; Omiti et al., 2009) are divided into three categories: household specific characteristics, market and institutional factors, and technical factors.

2.4.1 Market Distance

A major factor affecting crop commercialization according to Barrett (2010) and Omiti et al. (2009) is the distance of the crop producing household from a market. Most farmers tend to be less interested in commercialization when they are farther from a market. The long distances make it difficult to access markets. Studies (Barrett, 2010; Omiti et al., 2009) have shown that households that live further distant from market locations are less likely to participate in the market as a whole.

As put forward by Agwu et al. (2013), market location has a major impact on the participation in the market. Farmers' possibilities of commercialization are reduced if they live far away from markets. In addition, many farm households choose to sell their products at the farm gate, where the low pricing result in minimal returns. A study by Ochieng et al. (2016) concluded that marketable quantities as well as local market prices are typically influenced by the distance to markets which suggested that households located in rural areas had greater marketing expenditures than those who were closer to the marketplaces.

2.4.2 Farmer Based Organization

It has been observed that farmer-based organizations have an impact on the degree of commercialization since they share information. Governments and non-governmental organizations (NGOs) encourage the creation of FBOs to enhance

rural delivery of services, economic growth, and poverty reduction amongst farmers (Stockbridge et al., 2003). As a connection among producers, these FBOs also act as a platform for smallholder farmers, allowing them to communicate their demands that may be difficult to address as an individual farmer.

In developing countries, farmer-based organizations have been recommended as a significant instrument for improving the living standards of resource-poor farmers. Belonging to a farmers' association has a beneficial impact on smallholder farmers' income (Bachke, 2009). Farmer participation in such organizations has been shown to enhance the level of agricultural productivity, provide economic benefits to farmers, as well as improve their welfare through collective sales and marketing (Abdul-Rahaman & Abdulai, 2020 ; Shiferaw et al., 2011). When it comes to cooperating on mutually beneficial activities and investments, a competent producer organization will build the internal and external connections essential to achieve credible commitments from the parties involved. In addition, producers would be able to take part in the formulation and application of local development plans, the establishment of marketing and supply networks and the specification of public economic practices as well as the structure of a production/processing industry through their organizations. In as much as the membership of FBOs promotes commercialization, some studies (Rwelamira, 2015) posited that the members do face low commercial efficiency, little capitalization, huge debt, and restricted solvency as a result of their unbalanced organizational structures.

2.4.3 Technology adoption

The continued rise in food demand is crucial to increasing agricultural production. In increasing the production of food, agricultural technologies play a major role. It

is therefore necessary to see how technology adoption affects the commercialization drive of smallholder farmers through the level of production of agricultural produce. Agriculture technology encompass all sorts of enhanced techniques and practices that impact agricultural production growth (Jain et al., 2009). According to Birthal (2013), the most common technological development and crops promotion avenues are improved varieties and management plans, soil and fertility management, management of weeds and pests; water and irrigation.

Following on the positive stories of the Asian Green Revolution, attempts to raise agricultural output in Africa have focused on the adoption of better agricultural techniques. It is claimed that increased agricultural adoption of technology, such as the use of better seed types, might stimulate a shift away from low production, peasant, and subsistence agriculture and toward commercial farming (Mariano et al., 2012). Advanced crop technology adoption has the possibility of increasing agricultural output market share, allowing smallholder farmers' resource usage and output diversifying decisions to be progressively directed by their profit maximization goal leading to increased level of commercialization (Omiti et al., 2009).

The improved technology tends to enhance productivity and lower average production costs, which in turn will lead to significant increases in farm revenue, through commercialization (Pingali, 2007). The use of improved technology has been shown to promote productivity which subsequently leads to socio-economic growth. Improved farming methods have been connected with greater wages and rural family poverty reduction, improved nutritional status; decreased food costs, expanded employment opportunities. Jain et al. (2009) show that agricultural

technology non-appropriators barely have the potential and frequently lead to deprivation to sustain their marginal livelihoods and therefore leads to socioeconomic challenges.

As in commercialization, the adoption of agricultural technology is very vital. The use of improved agricultural technology with inputs will impact farmer's commercialization drive. A number of studies have demonstrated that the use of farm technologies not only reduces poverty but also generates advantages in terms of producing market surpluses in crop production. (Pingali, 2007; Kassie et al., 2011; De Janvry & Sadoulet, 2002). On the contrary, Braun et al. (1994) suggested that there might be more marketing without changes to agricultural technology in the short run but the reverse was less likely to happen because of the essential pull of technological innovation on the demand side.

2.4.4 Demographic Change

The influence of urbanization of economic growth is seen as driving factor on demand in smallholder marketing growth and demographic change (De Janvry & Sadoulet, 2002). The growth in urban population and stronger economic growth boost demand for commercialized agricultural products, increasing commodity prices and stimulating market agriculture output.

Population growth can delay the marketing process by placing pressure on farmlands, as food security becomes a priority for smaller farmlands over production. In addition, population stress can lead to deterioration of land and reduced production. The impact of population increase on marketing might thus be unclear (Martey, 2014). In Sub-Saharan Africa, the subsistence farmers are small-scale, rain fed, farmers with little or no irrigation (less than 0.5 hectares per household). Farmers

in the region also frequently recycle seeds and provide very little extra nutrients. Furthermore, agro-climatic and political circumstances often challenge smallholders which tend to affect the commercialization drive of these farmers (Boka & John, 2017)

2.4.5 Household Specific Factors

Demographic variables, such as age, sex, educational level, religion and marital status, affect the commercialization of agricultural products by households. The decision of a household to take part in the commercial market, as well as the type of crop that household's market are determined by the household characteristics including the size of a household, education, and literacy, age, and gender. Farmers' willingness to participate in a marketing plan has been proven to be favorably influenced by their gender (Abokyi et al., 2020). According to Drafor et al. (2005) in Ghanaian societies, women are more able to market vegetables and other household products than males. As a result, women have a superior awareness of the marketing process of pricing negotiation and identification of different marketing outlets.

Women are also more likely to visit the main market to sell agricultural products and purchase other household supplies. Although Hegena & Teshome (2022) discovered that women are more likely to engage in vegetable markets, Curry et al. (2019) discovered that males are more likely to engage in the export crop and fresh food market than women. While gender has no direct effect on commercialization, it influences the function of social and economic activities of the household head. Male farm households are predicted to have a favourable influence on commercialization in comparison to their counterparties, as men are generally more resourceful than women.

Several farmers' decisions, including whether or not to engage in markets and sell their crops, have been observed to be influenced by education (Zhang et al., 2021). It is suggested that education increases farmers' capacity to access and analyze market information, resulting in better knowledge of market programs. The more knowledgeable the head of the household is as the critical decision maker, the more critical the farmer is in the decision-making process (Wolanin, 2013). Moreover, education is an important factor in creating awareness of the market, with better educated farmers having a greater ability to receive and understand information about market information than less educated farmers (Abokyi et al., 2020. The influence of education on farmers' decision to engage in crop marketing might be negative or positive, depending on their capacity to receive and analyse information about alternative marketing channels, indicating that the orientation of the connection is unknown (Abokyi, 2022).

As put forward by Lambrecht (2016), in terms of ownership of land, family labour, farming decisions, amongst others, women headed households are likely to have restricted resources thereby limiting the capacity of women heads of household in producing marketable excess. The age of the household head can influence the output level in the market in various ways. According to Ehui & Tsigas (2009) older household heads are likely to have more dependants as households leading to higher spending, therefore reducing the level of commercialization as compared to younger household heads. Further Studies (Adegbola & Gardebroek, 2007) indicates that older heads of households may well have established long-standing relationships with institutions, making access to loans and land easier. The capacity of the farmers that includes the education, training, experience, skills have a beneficial influence on the commercialization drive of the farmer. This according to Siziba et

al. (2011) is because farmer capacity growth increases their capacity to appreciate market information, which may in turn reduce the cost of marketing and make it more lucrative to engage in commercialization.

The household size is used to describe the provision of low-cost family labour for production and should have a beneficial impact on commercialization. A larger household size alone, however, is not a necessary requirement, but the number of members who are active in households reflects family labour availability, contrasted to larger households comprised of a higher number of members who are just dependents. Larger households are likely to have more workers available. Farmers will be able to access and participate in a variety of marketplaces as a result of this. As a result, farmers are more inclined to join in markets that provide higher rewards, even if these marketplaces demand more effort to participate in. As a result, household size has a major impact on market involvement. Similarly, larger households have more agricultural labour available to them when they opt to engage in farm development, fertilizer application and other labour activities, both of which demand a lot more effort. Ma & Zheng (2022) found that household size had a beneficial influence on fertilizer utilization among Chinese wheat producers. The explanation for this result is that larger households are less likely to have labour shortages throughout the whole agricultural season, even during the height of the season, and hence use more fertilizer, which takes more work. Tafesse et al. (2015) discovered in Ethiopia that when family size increases, more labour is available for the household to leverage on, thereby seeking for different market outlets.

The choice to sell crops might be made jointly by the wife and husband. Yet, both may hold opposing viewpoints, which may diminish the likelihood of households

engaging in commercialization (Anderson et al., 2017). Similarly, both husband and wife's efforts might give many avenues for selling their items, reducing the likelihood of selling to buffer stock operators. In the case of investment, a married household is more likely to combine resources from both the husband and the wife, increasing investment capabilities.

Recent literature (Zamasiya et al., 2014;Siziba et al., 2011) have suggested that the ownership of communication mediums including radio sets, Television sets, mobile telephone facilitates commercialization through marketing information for farmers who have a favourable influence on the involvement in the output market. The existence of market information via these media would enhance the trust of farm households who are ready to commercialize. Furthermore, the ownership of transport and agricultural equipment such as motorbikes, trucks, tricycles, tractors have a beneficial effect on commercialization by decreasing production costs and the costs of carrying farm produce from farm to market. The asset base of the household is an essential element, with poorer households less likely to engage in high-value agricultural markets or succeed in their aspirations to become commercialized. Egbetokun & Omonona (2012) have suggested that age, marital status, labour, farming experience and farm size are the main drivers for farmers' engagement in commercialization.

2.4.6 Transactional Cost and Institutional Factors

It is necessary to analyse institutional settings and institutional arrangements to understand the impact of institutions in the commercialisation of farm households. Institutional environments relate to the basic forms of policy, social and legal framework underpinning the basis for production and commercialization. In this

regard, regulations on property law and contract rights are notable examples. As put forward by Oduol et al. (2008), institutional arrangements are the interactions between economic units which determine how they cooperate and compete. Market structures like agreements, auctions, exchanges, cooperatives are good examples. The activities of economic actors are made easier by formal institutions such as laws, constitutions, norms, regulations, contracts, rights of property and the legal framework (Dixit, 2009; Hodgson, 2006; Pejovich, 2006) These institutions have an overall impact on the commercialization process.

Available research (Chapoto et al., 2013;Jack, 2013;Daum & Birner, 2017) suggests that farmers in developing countries like Ghana are facing various forms of institutional challenges which impact their capacity to commercialize effectively in agricultural commodities. As a result, farmers primarily dispersed in rural areas suffer post-harvest losses owing to the lack of access to markets through effective choices on marketing channels. They do it for cheap prices in few cases, where they are able to sell excess after harvest. Most farmers will accept any prices once they are in a position to engage in informal commercialization due to a lack of knowledge of prices and pricing regimes (Wiggins et al., 2011). In Ghana, where a good number of rural farmers depend on traditional and subsistence agricultural, the current state of the available selling channels for agriculture, both institutionally and technically, has made farming very unappealing.

Transaction costs are significant factors that impede the search for information, negotiating contracts, monitoring and enforcement of prices and the expense of marketing products. In many situations, farm products purchasers like agribusiness owners are typically large and marketed and may use economies of scale, use market

power and negotiating authority over smallholder farmers (Ortmann & King, 2006). As stated by Pingali et al. (2005) smallholder farmers' low socioeconomic level, as well as deficiencies in transportation, processing, and storage facilities result in high transaction costs. Smallholder producers have minimal production capabilities, which means they can't alter output quantities quickly to suit market trends, and they can't keep up with cost-cutting technology developments, rendering them less effective in the market. However, contract farming agreements have the ability to achieve a guarantee of a market outlet that will help to reduce the cost of transactions for farmers on market access. There are several examples of contract agriculture agreements that lead to transaction cost savings for farmer groups (Bijman, 2008)

2.4.7 Agricultural Support Services and commercialization

Agricultural support services including agricultural extension according to Ferris et al. (2014) are being developed in order to connect small-scale farm workers with modern farming methods, and institutional structures such as agricultural marketing, services cooperatives. These institutions are able to assist the diffusion of technology and market information access. Smallholder farmers employ interconnection arrangements such as sharecropping, contracts between labour, credit, and land leases for the resolution of the market failure problems and market imperfections, as a matter of course for the farm producers. Fixed assets and short-term financing for working capital are also significant in easing access to long-term lending for rural financial institutions. Agricultural finance plays a key role in marketing, allowing smallholder farmers to take the risks of commercial cultivation (Martey et al., 2012). Agricultural Support services are necessary to enable smallholder farmers to try and enter profitable commercial agricultural markets. In many cases, farmers have the

right to access inputs and also to pay for the agricultural support services and market information (both individual farmers and groups formed as cooperatives). The lack of farm support services therefore constitutes principally an obstacle to the inclusive marketing of small farmers (Poulton et al., 2010).

Support services are also regarded an input in commercial agriculture. As commercial agriculture is regarded as a business, the farmer (owner of the industry) must pay for the expert advice needed for the industry's sustainability. Farmers who do not use profit-maximizing technology and procedures will not be able to thrive for long. Improvements in agricultural support services are desired so that smallholder farmers may be fully commercialized. Nevertheless, it is completely agreed that the sort of support services should be determined primarily by the country's levels of agricultural development. Additionally, even in a developed economy, some technologies, such as soil conservation is invariably a public good. Farmers in agriculture production demand a more personalized problem-solving service (Rossi et al., 2012). In the short term, extension information is exhaustible since the majority of farmers do not acquire it at the same time due to the slow pace at with which information is spread. Nonetheless, a significant quantity of agricultural support services such as fertilizer, seed, planting material, agro-chemicals, machineries, farm budgeting, farm planning, and so on, is classified as a private product, and commercialized extension services may fully meet these needs (Mukherjee & Maity, 2015). A commercialized extension service can provide both public and private products at the same time. They can charge for private commodities while providing public products for free. They may gain the trust and goodwill of the agricultural community by doing so. Commercialized agricultural support is invariably more productive and convenient than a state-owned, free

agricultural support because the life of such a program is relatively short if it is not efficient and successful. It is more influenced by demand than by supply. Furthermore, increased rivalry among commercial organizations may assist to enhance service quality. Better decision-making and evaluation of the implementation in commercial agencies will be an essential component in their high performance. A commercialized service, as opposed to a govt free extension service, caters for the individual demands of the clients.

Commercialized extension service includes advice to improve the integration of agricultural support advisory services and to make farmers intellectually active, implement innovative measures, taking account of the resource needs of poor farmers who, in many cases, do not have a titled land or other form of collateral.

2.4.8 Agricultural Commercialization and Household Consumption Expenditure

One important and complex factor in agricultural commercialization is how household consumption expenditure is affected by agricultural commercialization. Policymakers, academics, and practitioners should understand the effects of this shift on household consumption patterns as rural economies progressively move toward market-oriented farming techniques. Barrett (2010) found that increased household consumption spending and agriculture commercialization are positively correlated. He claims that more participation in commercial marketplaces raises farmers' incomes significantly and eventually increases their purchasing power. Barrett (2010) argument is that farmers who transition from subsistence to market-oriented farming might expand their reach into new consumer markets, diversify their revenue streams, and ultimately experience a noticeable rise in their total

income. As a result of this financial boost, households are able to manage resources more effectively, spending more on necessities like better healthcare, more educational opportunities and food security. This viewpoint emphasizes the potential for agricultural commercialization to address important social factors in addition to its economic benefits which will help enhance rural households' quality of life on a more complete level. According to Barrett (2010), this increased economic potential is critical in determining how people spend their money, especially on essentials like food, healthcare, and education. The reasoning is consistent with the more general viewpoint that market-oriented agriculture techniques serve as a stimulant for raising living standards and reducing poverty in rural areas.

On the other hand, Wineman et al. (2020) gives a contrasting viewpoint grounded on empirical data from sub-Saharan Africa. Their research casts doubt on the widely held belief that higher agricultural commercialization results in higher standards of living due to increasing purchasing power. Rather, the results examine the complex dynamics that households experience while adjusting to changing revenue streams and market-driven farming methods. They emphasize an important point that is sometimes missed in many models: how households involved in agriculture commercialization prioritize their spending. Although higher incomes from commercial farming might raise overall income levels, Wineman et al. (2020) point out differences in spending habits. Interestingly, households could spend money on things that aren't absolutely necessary rather than necessities. This casts doubt on the notion that improved general welfare is a direct result of increasing income and presents a possible challenge to nutrition and food security.

Furthermore, according to de Janvry & Sadoulet (2020), the impact of agricultural commercialization on household consumption expenditure depends on a number of variables, including the kind of crops that are marketed and market accessibility. They imply that, in comparison to those cultivating staple crops, individuals involved in high-value crops may see more notable benefits on consumer expenditure.

2.4.9 Agricultural Commercialization and Household Income

Agricultural commercialization's impact on household income has emerged as a central point in rural development and poverty reduction. The process by which agricultural activities shift from subsistence-oriented to market-oriented production where farmers sell excess output for a profit is known as agricultural commercialization. This change is frequently seen as essential to rural economies since it has the ability to raise farmers' incomes and improve their general well-being. However, the dynamics of this connection are complex and impacted by a number of variables, including governmental policy frameworks, market accessibility, and technology improvements. The benefits of agricultural commercialization on household income have been established in a number of studies. Reardon et al. (2009) underscored that farmer who participated in commercialization activities had a considerable boost in revenue as a result of their greater market engagement.

Leibbrandt et al. (2010), underscores the complexities of agricultural commercialization effects on household income, throwing light on the possibility of causing income inequality. Their research suggests that the benefits of commercialization may not be uniformly distributed across households, leading to

varying degrees of income increment. Factors such as initial resource endowments, access to markets, and the ability to adapt to market dynamics play pivotal roles in determining how different households experience the outcomes of agricultural commercialization. This highlights the importance of considering not only the average impact but also the distributional effects to comprehensively see the socioeconomic implications of market-oriented agricultural practices. Moreover, Leibbrandt et al. (2010) contend that exogenous variables, such as fluctuations in the market and infrastructural challenges, may impede the effects of commercialization into enhanced household income. These divergent points of view clarify the complex nature of the relationship between household income and agricultural commercialization.

2.5 Measurement and Models Used in Commercialization Studies

In the analysis of commercialization and the level of commercialization by farmers, it is imperative to assess the decision to commercialize or otherwise and to also assess the intensity of the commercialization. The factors that are observed and unobserved, which affect commercialization and degree of commercialization, differ in many ways (income level, farmers access to various support services, etc). Commercialization and commercialization intensity can therefore be endogenous. In order to prevent poor estimations of outcomes, this possible selection bias must be taken into consideration when analysing commercialization and intensity of commercialization. The option on commercialization (whether to commercialize or not) and degree of commercialization in the output market are not random variables to smallholder farmers and (the quantity of produce to commercialize) is controlled by the farmer on the output market. These assumptions are founded on the premise that the households decide on two independent options; the decision to

commercialize in a market, and the quantity involved (measured either by probit or logit models) (Martey, 2014).

The probit model is used in commercialization studies because the dependent variable is dummy or divides into two stages and the model is easier to examine the determinants of farmer's commercialization. However, a major weakness of the probit model is that the results of commercialization does not differentiate between households who sell a little part of their produce and those that sell a large proportion of their agricultural products. Several models have been adopted to meet the challenge of the probit model.

The switching regression model (Di Falco & Veronesi, 2011; Kassie et al., 2014) are common approaches that are two steps inclined which are often adopted. Two step approaches are of the assumption that commercialization is made up of two decisions namely the decision to commercialize or not to commercialize market and the second which is how much output to commercialize with if a given household decides to participate in the first stage. According to Martey et al. (2012) the commercialization intensity is evaluated by the Tobit model. The Tobit model is of the assumption that the commercialization decision and intensity are determined simultaneously by the same factors.

In assessing the effect of commercialization on consumption expenditure, farmers opt to commercialize if they think that the net profit from commercialization in the form of consumption expenditure is greater than non-commercialization. Moreover, other unobserved factors also influence farmers choice to commercialize leading to selection bias. There are some unobservable characteristics of the household that

influenced their per capita consumption expenditure and, in this regard, the source of the endogeneity problem is self-selection

Bias and failure to consider such problems will overestimate the true impact commercialization has on household consumption expenditure. Therefore, an estimation method is needed to correct this bias and obtain an unbiased estimation. Factors that are unobserved impact both the error terms and the outcome equation. The unobservable factors might include personal, social and institutional factors. This creates a link between the selection error terms and the continuous equation. This connection of error terms indicates the presence of an endogenous switching (Maddala, 1986). The approach of endogenous switching presumes that there are two decisions for commercialization (Abu & Haruna, 2017) .The first is the choice to commercialize or not to commercialize and the second which is how much the output to commercialize if a household agrees to take part in the first stage, participate with.

A double-huddle model is also another model that is used in commercialization studies and it is useful for choices not taken jointly or choices that are not taken together. The Double hurdle model is a model in which two independent stochastic procedures affect the choice to commercialize and the level of commercialization (Cragg, 1971). It entails performing a probit regression on the choice to commercialize using all of the factors from the first step. This is proceeded by a regression model that is truncated on commercialized households. According to Hitayezu et al. (2017) double hurdle is used in situations when an event can occur or may not occur and if it happens, continuously positive values are assumed. In the

decision-making process, the farmer faces hurdles. The choice to market will first be taken and afterwards decision on intensification.

2.6 Measurement of Welfare

Scholars have fiercely argued the advantages and disadvantages of many welfare measures, with a strong agreement favouring consumption above income, particularly in developing countries. First and foremost, individuals gain material well-being from the actual consumption of goods and services instead of from the receipt of income (Citro & Michael, 1995); hence, consumption appears to encompass the idea of living standard.

According to Deaton & Zaidi (2002) consumption better represents long-term income because it is less sensitive to short-term variations in income and is smoother and less volatile than income. Seasonal trends are more likely to affect income, resulting in either an underestimating or an overestimation of real income. While collecting data on consumption takes time, the idea of consumption is frequently simpler than the concept of income. As a result, precisely measuring household income is challenging, particularly for self-employed households and those working in the informal sector. There are, however better approaches and to follow when attempting to establish an accurate estimate of consumption (Deaton & Zaidi, 2002).

Consumption should be extensive in order to acquire a decent measure of welfare (Deaton & Zaidi, 2002).Obtaining data on only a subset of consumption may lead to bias. As Deaton (2005) indicated as the connection between the part and the whole might vary a great deal from one household to another and from one place or time to another, excluding some components may alter the results. Consumption typically consists of the following components: 1) food consumption, 2) non-food

consumption (including health, education, and other non-food expenditures), 3) housing expenditures (including rent and utilities), and 4) consumer items. Food consumption includes food consumed within the household from various sources (purchases, self-produced food, food received as presents, transfers, and payments in kind) as well as food consumed outside the households (restaurants etc.).

Education (student fees, reading materials, etc.) and health (healthcare care and health expenses) are examples of non-food products, as are a variety of other non-food expenditures (such as domestic fuel and power, tobacco products, clothing and footwear, transportation, recreation, personal care, miscellaneous goods and services). Nonetheless, a decision must be taken about which items to include. It is normally advised to include schooling expenses and to omit taxes, levies, donations, and transfers (Deaton & Zaidi, 2002). Lastly, consumer durables are an essential category to analyse. When dealing with permanent products (such as a house, a car, a washing machine, a computer, and so on), the flow of services that they produce should be estimated rather than the spending itself. However, in order to calculate this flow of services for durable goods, data is required on the age of each durable good as well as on its original and current value. In practice, estimating the value of service flows also involves crucial suppositions such as description of durable good, depreciation rate of different items and so on (Deaton & Zaidi, 2002)

2.7 Review of Empirical Literature

Donkoh (2020) evaluated factors that influence the commercialisation drive and the effect of the factors on the adoption of improved agricultural technologies (IATs). Data was collected from 543 farm households in northern Ghana. The estimation model was the Endogenous Poisson model. It was revealed from the findings that

commercialisation improves IAT adoption and is influenced by characteristics such as off-farm activities, rice yield, sex, family headship, farm size, credit, and commercial centre location. Age, experience, mass media information sources, and home-to-farm distance all affected the likelihood of adopting IATs. It was recommended that Stakeholders should focus on the youth and increase their efforts to support programs such as "Planting for Food and Jobs" and "Planting for Export," as well as livelihood diversification programs.

Tafesse et al. (2020) assessed the determinants of agricultural commercialization in Offa district, Ethiopia. A semi-structured questionnaire was used to collect data from 120 randomly selected households. To explain the output market participation and difference in the output market participation, the data were examined using descriptive and inferential statistics. The Tobit model was utilized to identify determinants of smallholder commercialization. The regression took 11 explanatory variables into account. Total cultivated land area, education, household head age, and availability of transportation were found to be significant determinants of farm output side commercialization intensity. Regarding development authorities, these characteristics should be considered in the formulation, promotion, and execution of policies and programs aimed at increasing rural household involvement in commercialization and ensuring its advantages in the region.

Seng (2016) examined the effects of market participation on farm households' food security in rural Cambodia using household dietary diversity score as a proxy. An endogenous witching model was used to carry out the study and the model was built on data from the Cambodia Socio-Economic Survey (2009). The endogenous switching controls for selection bias caused by latent factors that may have an impact

on both market participation and food security. In terms of food security functions, the model also accounts for structural disparities between market participants and nonparticipant. The findings show that by engaging in markets, farm households have a better household dietary diversity score, confirming that market participation has a beneficial influence on the food security of farm households.

Opondo & Owuor (2018) assessed the effect of cassava commercialization on household income of smallholder farmers in arid and semi-arid land (asal), using kilifi county as a case study. The study developed commercialization index which has the integration of both value addition and market participation. The endogenous switching which controls for selection bias caused by latent factors was adopted to assess the effect of commercialization on household income. Factors influencing cassava commercialization for Kilifi County which are significant were farm size, off-farm income, age and distance to market. Particularly, the off-farm income and remittances also had significant impact on household income. It was concluded that, farmers who undertook cassava commercialization enjoyed more income relative to those who did not.

A study on the market participation of smallholder farmers in Ghana was carried out by Musah et al. (2014). The aim of the study was to analyse market participation levels, the extent to which smallholder maize and groundnut farmers participated and market constraints. 400 farmers were chosen randomly in four agricultural districts in the region using a multi-stage sampling method. Market participation using the household commercialization index was computed. To evaluate the influence of market participation and intensity, a double hurdle model was employed. The Garrett ranking analysed the constraints on marketing

production. The results revealed that the marketing output for maize and groundnut was low and moderate respectively. In terms of likelihood and intensity, farmers' characteristics were observed to be the influencing factors (gender, household, age, education), public and private assets (extension contacts, prices, loans, farm size, production and experience) were also influencing factors as well as the costs associated with transactions. Unfavourable market pricing is considered the highest and government marketing policies were the least constraint in terms of marketing. The study concluded that maize is produced as a staple while groundnut is produced as a cash crop. The study revealed that whereas groundnuts were grown as cash crops, maize was cultivated as a staple. It is recommended that the Government should institute policies to boost productivity and marketable farm household surpluses, meet smallholder loan requirements and enhance the provision of information on the agricultural market.

Kirui & Njiraini (2013) in their study on "the determinants of agricultural commercialization among the rural poor: role of ICT, Collective Action Initiatives and gender perspective in Kenya" aimed to address gaps in the literature in particular through the complete conceptualization of household-level and diverse socio-economic and agro-ecological marketing drivers (mobile phones) based on the promotion of collective action initiatives and the modern yet challenging penetrating ICT mechanisms. The objective of this study is to emphasize the factors of farm output commercialization by farm households in Kenya (market involvement). Specifically, the role played by sex, collective action efforts and ICTs as well as their interplay among agricultural households in Kenya are given specific attention. The study employs a Tobit regression model to evaluate commercialization determinants based on data from 379 agricultural households in

three Kenyan regions. The study found that commercialization is affected by farmers-specific factors, farm specific and capital requirement. Furthermore, the farmers' organizations and the usage of ICT tools (mobile phones) have an important and beneficial impact on marketing. Female farmers have limited market involvement. The policy and practical consequences are explored.

Martey et al. (2012) assessed Commercialization of smallholder agriculture in Ghana by employing a Tobit regression analysis. The study evaluates the trends in Ghana's agricultural household maize and cassava production and estimates the commercialization levels of those two commodities. The magnitude and direction of factors that affects the intensity of the marketing of farm households are also measured by means of the Tobit regression analysis. The results show a higher yearly rate of cassava output growth than maize output. The study found that the level of commercialization is determined by output price, agricultural land size, households with access to extension services, distance to market and market information. These findings have consequences for Ghana's agriculture strategy. Road network from farms to markets are recommended from the study to be upgraded, Retail outlets in farming areas should be expanded and the transportation costs should be minimal in the farming areas and the encouragement of rural farmers to trade in marketable commodities. The data collected and analysed was cross sectional.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the methodology employed for the study. Firstly, the study area, the approach to the study, population and sample size was defined. Furthermore, the variables in the study were defined in this chapter. The section also outlined all the econometric analysis that were performed based on the objectives set for the study.

3.2 Profile of Study Area

The study includes smallholder rice farm households from the Northern region of Ghana. The region is among Ghana's impoverished and least developed. Agriculture is the backbone of the population in the area, so the bulk of the economically active group in northern region is involved in agriculture (GSS, 2010). The Northern Region is bounded on the north by the North East region, on the east by the international boundary between Ghana and Togo, on the south by the Oti region and on the west by the Savannah Region.

The inhabitants of the region are mostly subsistence food crop growers with the majority of the population residing in rural areas. Rice, millet, maize, sorghum, yam, groundnut, cowpea, and soybean are the major crops cultivated. Agriculture employs over 70% of the economically active rural population in the Northern region (MoFA, 2016). The region covers a total land area of 25,448 km2 (9,826 sq. mi) and having an estimated population of approximately 2,479,461 (GSS, 2010)

The selection of the region is centred on the area's high rice production capacity. The region is characterized by a rainy season that begins in April and progressively

increases to a climax in August/September before gradually decreasing by October/November (GSS, 2014). Additionally, there is the dry season that lasts from November through to April, with a maximum in February each year (GSS, 2014). This season is also marked by dry harmattan winds that envelop Ghana's northern regions. The regions' vegetation is primarily Guinea savannah, with its distinctive grasses and trees. The types of tree vegetation were abundant in the past but it is presently declining owing to deforestation. The region's climate is rather dry, with a single rainy season that lasts from May to October. The quantity of rainfall reported each year ranges between 750mm and 1,050 mm. The dry season begins in November and ends in March/April, with temperature increase in March and April and minimum temperature in December and January. The harmattan winds, which blow from December to early February, have a significant impact on the region's temperature causing them to range between 14°C at night to 40°C during the day. The low humidity enhances the effect of the afternoon heat. Four districts were selected for the study and these districts were selected as a result of the high rice production and marketing potential. The districts selected include Tolon, Kumbungu, Savelugu and Sagnerigu District.

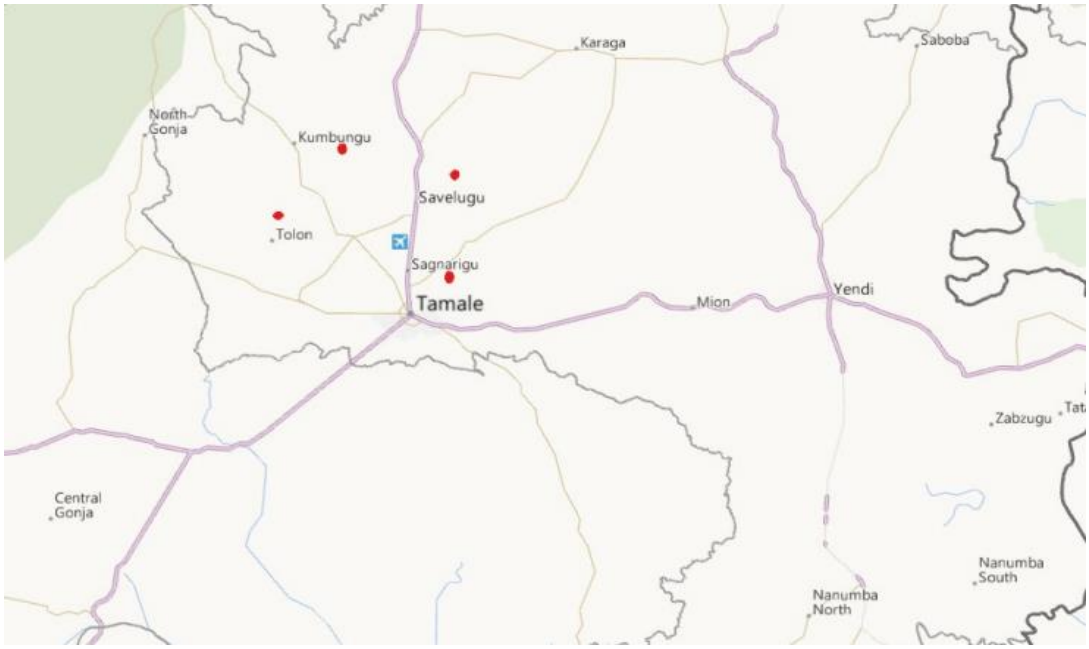

Figure 3. 1: Map of Selected District

Source: GSS (2014)

3.3 Research Design

A research design refers to a detailed outline of how an investigation will take place. Case and field research designs, exploratory research designs, surveys, time series design, experimental research design, and quasi-experimental research design are among the research designs we have. Research design according to (Kemmis et al., 2014), is the overall strategy that is chosen to blend various components of the study in a logical and coherent way that ensures that it addresses the research problem in an effective and logical way. The quantitative research design specifically the quasi-experimental research design was used in the study. The study used the quantitative research approach to ensure that the impact of rice commercialization on welfare were objectively, with reliability and statistical strength. This particular approach has allowed the collection of quantitative data and its statistical consideration for patterns or relationships and causal effects to evaluate the impact. The study, in measuring the impact of commercialization, used a quasi-experimental research design to

compare groups of farmers based on the extent of their participation in markets. A survey of a cross-section of farmers was used to acquire the quantitative data needed for the study. The decision to use cross-sectional data rather than panel or time series data was driven by the availability of data for analysis at the time the research was conducted. Furthermore, the researcher was unable to gather data on the same respondents across time in order to explore panel or time series modelling.

3.4 Population and Sample Size

The population of the study are rice farmers in the Northern region of Ghana. Rice farmers of the four districts in the Northern region were considered for the study due to their ease of accessibility in terms of their geographical location and the intensity of rice production in these areas. The districts include Savelugu Municipal, Tolon District, Sagnerigu district and Kumbungu District. According to GSS (2018), 82,170 Farm households in the Northern region cultivate rice. Notwithstanding, due to cost and time restrictions, the entire population of rice producers could not be surveyed.

As a result, sample size determination is required. The sample size is determined using Slovin's (1960) formula, which is used to compute sample size when limited information about the population is available (Ryan, 2013). This was done using the equation as follows:

$$n = \frac{N}{1+Ne^2} \quad \text{.....(3.1)}$$

In representation, n is the sample size and e is the margin of error (0.05 with a 95% confidence level). N is the population of rice farmers in the Northern region, which in this research is 82,170 farm households. The sample size (n) is calculated as 398

after substituting the values. The sample size was adjusted to 420 to account for any questionnaire design errors that may have occurred. There was equal density given to the four districts considered for the study in terms of sample allocation.

$$398 = \frac{82{,}170}{1 + 82{,}170(0.05^2)}$$

3.5 Sampling Procedure

Commercialization studies most often gather data from a cross-sectional sample of farmers in the target communities. In this study, a multistage sampling procedure was used to choose respondents from rice producing communities in the Northern region of Ghana. The Northern region was purposively sampled for the study because of the high level of rice productivity in the region. The Northern region is the second largest producing region of rice in Ghana (GSS, 2018).

In the second stage of the sampling process, a purposive sampling was also used to select the four districts namely the Savelugu municipal, the Kumbungu district, the Tolon district and the Sagnerigu district. These districts were purposively selected as a result of the ease of accessibility and the high level of rice production in the districts. Furthermore, these districts have wide spread of land for the rice cultivation.

In the third stage of the sampling procedure, the study employed a simple random sampling technique to select 20 communities from the four districts of study. The simple random technique was however employed to select 5 communities each from the four districts. In the fourth and final stage of the sampling process, a simple random technique was again employed to select 21 farm households per community and in all 420 respondents were selected for the study. Comparability and statistical balance across the study districts were further enhanced by ensuring that each of the

selected communities had equal numbers of respondents. The study maintained equal representation by selecting 21 farm households per community to reduce biases that could emanate from unequal sample sizes. This enhances the validity and reliability of the findings to ensure that any observed differences in commercialization and welfare outcomes are not due to sampling inconsistencies.

3.6 Types, Sources of Data and Data Collection Instruments

The study collected cross-sectional data from household survey of rice farmers in the selected districts. The data was collected through a questionnaire designed to solicit information from the rice producing households in the region. The questionnaire was programmed into the ODK data Collection Software and taken to the field for data collection after which the data was imported from the ODK server into the STATA 14 software for data analysis. The main components of the questionnaire include questions on Socio demography of the respondents, Questions on rice production and commercialization, questions on welfare measures such as the dietary diversity, income levels, consumption expenditure and asset ownership and questions on support services in agriculture. Pretesting of the questionnaire was done with the use of 15 questionnaires in the Tolon District. The pretesting was done to identify errors and other irregularities in the questionnaire which were all corrected prior to the commencement of the field work.

The data was collected by 5 trained enumerators and supervised by the researcher. The enumerators were trained on the questions and how to enumerate them on the field. All the enumerators were fluent in English language and Dagbanli which is the common language among the inhabitants of the selected districts. There was however no language barrier to the enumerators. The data was however collected between

March and April 2022. The data included information on the 2021 production season which ended in December 2021.

3.7 Data Analysis

The data analysis was done for the four objectives of the study using STATA 14 software. All the econometric estimations and statistical representations were presented using tables and graphs and these are found in Chapter four of the study.

3.7.1 Theoretical Framework of Commercialization and Welfare

3.7.1.1 Utility Maximization Model

A measure of relative human satisfaction is referred to as utility. It is frequently depicted as being influenced by the consumption of different products and services, the ownership of wealth, and the expenditure of free time. Farmers cultivate land to meet their physiological demands for food and/or to increase their wealth by commercializing their agricultural activities (Otekunrin et al., 2019). Utility functions assess producers' preferences for wealth as well as the amount of risk they are ready to accept in order to achieve greater wealth. Smallholder farming households make decisions regarding what sort of crop(s) to grow, how much to cultivate, and when and where to sell or market the output to maximize the pleasure from their labour in terms of returns. The underlying assumptions that people want to maximize utility within the constraints of their budgets and that people seek to maximize welfare has a long history in economic philosophy. A utility maximization model is a consumer behaviour model that makes assumptions about how people make decisions and how much utility a person gets from the decision made (Foxall et al., 2007). Researchers use utility maximization to presume that persons make logical decisions based on the returns they get from the decision that is made.

Nishizawa (2021) defined welfare to encompass the ability of man to earn money and obtain material satisfaction. Farmers' welfare is said to be achieved when a farm household is able to obtain sufficient, reliable, and sustainable incomes from farm and non-farm activities that is not only adequate to fulfil the various needs connected with social dignity, but also leaves with savings that can be invested back into farming.

According to Osmani & Hossain (2015), commercialization is a decision that is made by the farm household as to the quantity of the produce to sell and that not to sell. Commercialization therefore integrates the farm households into both the domestic and the output market as they can get the opportunity to participate in the market in order to gain revenue from their production. The utility maximization model therefore defines farm households who commercialize as rational consumers in the market who make best decisions that enhances their welfare or have welfare effects on them.

Rice-producing households are assumed to optimize their utility in the face of limitations that impact their propensity to commercialize. The utility which is the welfare from commercializing rice is represented by U_{i_1}, whereas the utility from not commercializing is provided as (U_{i_0}). The net utility of both can be denoted as U_{i_N}, such that a utility or welfare maximizing household will decide to commercialize rice if and only if the net utility gained from commercializing exceeds the utility gained from not commercializing (U_{i_N}= U_{i_1} -U_{i_0} > 0). The framework employed in this study is a random utility framework that has been adopted to model commercialization decisions of smallholder rice farmers and the gains or welfare they

achieve through the commercialization. The random utility model employed is modelled as indicated below

$$U_i^* = X_i'\beta + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

$$U_i = \begin{cases} 1, if\, U_i > 0 \\ 0, \ otherwise \end{cases}$$

U_i=latent variable that represents the probability of a household to commercialize which take the values of 0 and 1

X_i'= explanatory variables explaining the participation decisions of rice producing households.

β=vector of parameters to be estimated.

ε_i =The error term

From the model, a rice farmer decides to commercialize the rice produced if and only if the utility derived from commercialization is higher than the utility derived when he or she does not commercialize. In this regard, the theory of utility maximization is used to assess how smallholder rice farmers make decisions on whether to commercialize or not commercialize.

3.7.2 Conceptual Framework of Commercialization and Welfare

The conceptual review of the study is based on the premise of Barrett (2010) that location factors including the size of the farm, how motorable the road to the farm is, the distance from the farm gate to the input and output markets, technological factors namely the access to improved seeds, ownership of media devices, ownership of transportation machines and institutional factors including the membership of FBOs, the access to farm credit and the access to extension services all determine the yield of rice. The yield also determines the commercialization decisions of the farmers, commercialization also determines the yield as proceeds from commercialization can

be used for more production and finally, the decision of the farmer to commercialize the rice or not determines the income and the per capita consumption expenditure of the farmer. On the other hand, socio economic factors including the sex of the household head, the age of the household head, the household size, the educational level of the household head and other factors such as remittances and non-farm income and labour all affect the commercialization decisions of farm households which determines the income level of the households and their per capita consumption expenditure. This is illustrated diagrammatically in Figure 3.2

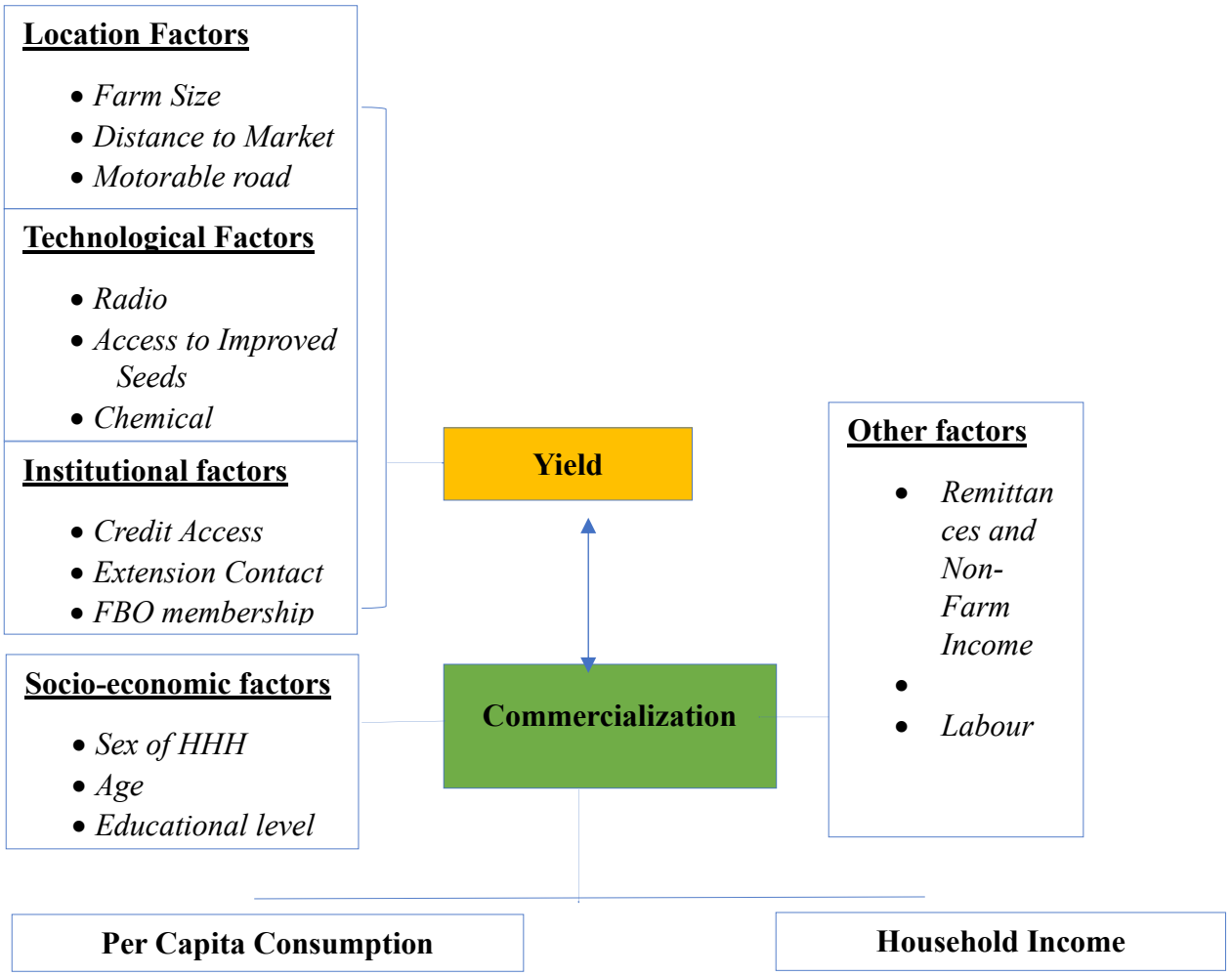

Figure 3. 2: Conceptual Framework

Source: Barrett (2010)

3.7.3 Determinants of Commercialization

The decision to engage in the rice market as a net seller or a net buyer is "dichotomous" in nature, according to theory. Households participate in a market regime that optimizes their expected utility over market regimes that do not optimize their utility. According to literature, various exogenous variables such as household characteristics, socioeconomic factors, access to information and location factors, institutional factors, and plot characteristics impact the decision to commercialize agricultural produce.

The probit model is employed to model binary or dichotomous outcome variables. The inverse standard normal distribution of probability is described as a linear combination of predictor variables in the probit model (Breen et al., 2018). The study models commercialization as binary which is the likelihood of commercializing rice or not based on certain variables or determinants. A probit model is a common specification for a binary response model with a probit correlation. The standard maximum likelihood technique is most commonly used to estimate this model. In the probit model, commercialization is measured as a binary measure such that it takes on two values: 1 if the farmer commercialized rice and 0 if he/she did not commercialize rice.

Linear models are another name for binary response regression models. The ordinary least square regression (OLS) cannot be employed due to the issues of non-normality of the error term, heteroscedasticity of the error term, and the likelihood of the probability value falling outside the 0-1 bracket. The Cumulative Distribution Function can be used to describe binary response variables in regression models.

According to Gujrati (2003) one of the CDFs typically used to describe the 0-1 response is the probit model.

A standard binary dependent variable model assumes that Y^* is formed through a classical linear regression model of the form:

$$Y_i^* = X_i^T\beta + \mu_i \quad \text{.....3.4}$$

From the definitions above, Y_i^* is a continuous index variable for the observation I which is latent or unobserved. X_i^T is a 1xK vector of rows of independent variables for observation i, β is a column vector for the regression coefficients and μ_i is the is the random error term for the observation i. As outlined by Wooldridge (2003), the specification is as follows:

$$Y_i = \begin{cases} 1, for \;\; Y^*{}_i > 0 \\ 0, \; for \; Y^*{}_i \leq 0 \end{cases} \quad \text{.....3.5}$$

In specification, the functional form of the binary probit model is assumed to take the form of $P_r(Y = 1|X) = \varphi(X_i^T\beta)$. where P_r denotes probability, and φ is the Cumulative Distribution Function (CDF) of the standard normal distribution. The parameters β are typically estimated by maximum likelihood. When likened to using an arbitrary mean and standard deviation, using the standard normal distribution causes no loss of generality because adding a fixed amount to the mean can be compensated by subtracting the same amount from the intercept, and multiplying the standard deviation by a fixed amount can be compensated by multiplying the weights by the same amount.

Although the probit parameter computation does not reveal how much a single variable improves or reduces the probability of commercialization, the residual effects of the predictor variables on the likelihood of participation of the smallholder rice farmer have been taken into account. According to Franken et al. (2022), the

residual impact for the constant independent variables was calculated by multiplying the variance estimation by the normal probability density equation while maintaining the individual factor variables at their mean values. The residual effects of the null-independent variables have been assessed by calculating the likelihood of the outcome as the null variables take their two distinct values.

Finally, the log-likelihood approach was used to quantify the parameters, which was then maximized to obtain parameter estimates and subsequent marginal effects. Generally, the parameters β are estimated using the maximum likelihood approach, which is denoted as

$L(\beta) = \prod_{i=1}^{n}[\varphi(x_i'\beta)]^{yi}\,[1-\varphi(x_i'\beta)]^{1-yi}$…….3.6

Taking the log of both sides in equation 3.6 gives us the estimates of the log likelihood which is

$lnL(\beta) = \sum_{i=1}^{n}\{y_t ln[\varphi(x_i'\beta) + (1-y_i)ln[\varphi(x_i'\beta)]]\}$……3.7

This log-likelihood function is globally concave in β and standard numerical algorithms for optimization will converge to the unique maximum.

Model Specification

The probit model specified in this study to assess the determinants of smallholder rice commercialization can be expressed as follows

$Y_I = \beta_0 k_0 + \beta k_1 Age + \beta k_2 Sex + \beta k_3 Farmsize + \beta k_4 Edu + \beta k_5 Rice\ Exp +$

$\beta k_6 HHsize + \beta k_7$Labour $+ \beta k_8 Livestock + \beta k_9 Credit\ access +$

$\beta k_{10} Own\ Tv + \beta k_{11} Ext\ Contact + \beta k_{12}$FBO $+ \beta k_{13} Radio + \beta k_{14} Motorbike +$

$\beta k_{15} Qnty\ Mobile\ Phone\ + \beta k_{16} Distance\ home\ to\ Market +$

$\beta k_{17} Motorable\ road + \beta k_{18} Improved\ Seeds + \mu_i$

Hypothesized Variables

The following table presents the potential variables which are expected to influence the decision to commercialize or not to commercialize rice by the smallholders.

Table 3. 1: Binary Probit Hypothesized Variables

Variable	Description	Measurement	Expected Sign
Dependent Variable			
Y	Sold Rice	Dummy: 1=if yes, 0=Otherwise	
Independent (Explanatory) Variables			
X_1	Age	Count=Age (years) of Household Head	+/-
X_2	Sex	Dummy=1 if Male, 0= if Female	-/+
X_3	Farm Size	Count=Size of farm cultivated in Acres	+
X_4	Education	Count: Number of years of schooling of HH head	+
X_5	Rice Experience	Count: Years household have cultivated rice	+
X_6	HH Size	Count=Total number of members in the household	-
X_7	Labour	Count=Total number of people who worked on the farm	+
X_8	Livestock Owned	Count=Total number of livestock owned by Household	+/-
X_9	Credit Access	Dummy=1 if Yes, 0 Otherwise	+
X_{10}	Tv Owned	Dummy=1 if Yes, 0 Otherwise	-
X_{11}	Extension Contact	Dummy=1 if Yes, 0 Otherwise	+
X_{12}	FBO membership	Dummy=1 if Yes, 0 Otherwise	+
X_{13}	Owned Radio	Dummy=1 if Yes, 0 Otherwise	+/-
X_{14}	Owned Motorbike	Dummy=1 if Yes, 0 Otherwise	+
X_{15}	Quantity of Mobile Phone	Count=Total number of mobile phones owned by household	+
X_{16}	Distance from Home to Market	Count=Distance in Km from home to the nearest market place	-
X_{17}	Motorable Roads	Dummy=1 if Yes, 0 Otherwise	+
X_{18}	Access to Improved Seeds	Dummy=1 if Yes, 0 Otherwise	+/-

3.7.4 The impact of Rice Commercialization on Per Capita Household Consumption Expenditure

As previously stated, commercialization is modelled by the Random Utility Theory (RUT), which states that farmers would select between commercialization and non-commercialization based on the benefit they will get. Farmers are believed to be risk averse, and their decision to engage in commercialization is impacted by the benefit they would get from Commercialization. Rice farmers are consequently expected to choose the market participation choice that would give them with the most benefits (Barrett, 2010)

Farmers decide to commercialize if they assume that the net returns of commercialization in terms of farm revenue are greater than the net benefits of not commercializing. A number of unobservable factors influence farmers' decision to commercialize, resulting in a selection bias. Unobservable factors can impact both the error term in the selection equation (μ_i) and the outcome equation (ε). Unobservable factors can be classified as personal, institutional and social characteristics. Management and technical abilities, farmer-to-farmer networks, and informal associations to formal organizations such as market groups are examples. They may also include transaction costs imposed by farmers (Abdulai & Huffman, 2014).

The easiest technique for analysing the influence of commercialization on per capita consumption expenditure would be to add a dummy for commercialization or use as a variable in an OLS model. Nevertheless, Ashenfelter & Greenstone (2004), argue that this technique may result in the estimation of biased estimates since the model implies that the decision to commercialize is exogenously determined, whereas it

may really be endogenous. Farmers self-select into market participants and non-participants endogenously, hence there is a chance that decisions are impacted by some unobservable factors connected with the result under discussion. The right estimate technique must be used, and the Endogenous Switching Regression (ESR) approach was used to account for selectivity bias. ESR takes into consideration self-selection bias and the interplay of individual practice decisions.

Given that distinct farm and farmer factors influence whether or not a farm household decides to commercialize, the following specification provides the result regression equations for the two regimes: This leads in a correlation between the selection error terms and the continuous equation: corr (ε_i, μ_i) = $\rho \neq 0$. According to Maddala (1986) This link between error terms demonstrates the presence of endogenous switching.

The Endogenous Switching regression is a two-step process (Kassie et al., 2014; Kabunga et al., 2012) that starts with estimating a selection equation (Eqn 3.4) to examine the determinants of commercialization decisions of smallholder rice farmers. The impact of commercialization on per capita household consumption expenditure is calculated in the second step by describing two regimes of outcome equations for those who commercialize and those who don't commercialize. The Model is estimated by specifying two regimes of outcome equations for participants and non-participants in commercialization.

Regime 1 $Y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$ if $D_i = 1$……..3.8

Regime 2 $Y_{2i} = \beta_2 X_{2i} + \varepsilon_{2i}$ if $D_i = 0$…….....3.9

The dependent outcome variables Y_{1i} and Y_{2i} are determined by the exogenous factors. The parameters $X_{i,}$ β_1 and β_2 reveal the direction and intensity of the

relationship between the outcome variable and the independent variables. ε_{1i} and ε_{2i} are both the error terms.

There are several ways for estimating the endogenous switching model. By estimating one equation at a time, two step least squares or maximum likelihood estimation may be employed (Lokshin & Sajaia, 2004). Nonetheless, these techniques are cited as inefficient and resulting in heteroskedastic residuals since they require 'cumbersome adjustments' to produce consistent standard errors (Abdulai & Huffman, 2014). This limitation can be overcome by estimating the model with the Full Information Maximum Likelihood (FIML) method.

The specification for the two regimes are given as follows

Commercialize: $Y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$ if $D_i = 1$……..3.8

Not Commercialize: $Y_{2i} = \beta_2 X_{2i} + \varepsilon_{2i}$ if $D_i = 0$…….....3.9

Suppose the error terms ε_{1i}, ε_{2i} and μ_i have a trivariate normally distributed characteristics with a mean vector of zero and a covariance matrix.

$$cov(\mu_i, \varepsilon_{1i}, \varepsilon_{2i}) = \begin{bmatrix} \sigma_\mu^2 & \sigma_{\varepsilon 1\mu}^2 & \sigma_{\varepsilon 2\mu}^2 \\ \sigma_{\varepsilon 1\mu}^2 & \sigma_{\varepsilon 1}^2 & \sigma_{\varepsilon 1}^2 \\ \sigma_{\varepsilon 2\mu}^2 & \sigma_{\varepsilon 1}^2 & \sigma_{\varepsilon 2}^2 \end{bmatrix} \text{……3.10}$$

Where σ_μ^2 represents the variance of the error term in the selection equation and $\sigma_{\varepsilon 1}^2$ and $\sigma_{\varepsilon 2}^2$ represent the variances of the error terms in the continuous equations. $\sigma_{\varepsilon 1\mu}^2$ and $\sigma_{\varepsilon 2\mu}^2$ are the covariances of μ_i and uε_{1i} and ε_{2i} and respectively. Y_{1i} and $Y_{2i}$are not observed at the same time, the covariance of the associated error terms is not determined (Maddala, 1986). This error term structure indicates that the error terms of the outcome equation and the error term of the selection equation are associated, resulting in a non-zero expected value of ε_{2i} and ε_{2i} given μ_i - error term of the selection equation (Abdulai & Huffman, 2014). As a result, the error term in

equation 3.10 depending on the sample selection criterion, have non-zero expected values and ordinary least squares estimations of the coefficients Y_{1i} and Y_{2i}. Due to this, the following are the expected values of the trimmed error terms

$E(\varepsilon_1 \mid D = 1)\ and\ E(\varepsilon_2 \mid D = 0)$ are as represented below

$$E(\varepsilon_1 \mid D = 1) = E\left(\frac{\varepsilon_i}{\mu} > -Xa\right)$$

$$= \sigma\varepsilon_1\mu \frac{\theta\left(\frac{Xa}{\sigma}\right)}{\pi\left(\frac{Xa}{\sigma}\right)} = \sigma\varepsilon_1\mu\ \gamma_1 \quad \text{.....3.11}$$

and

$$E(\varepsilon_2 \mid D = 0) = E\left(\frac{\varepsilon_2}{\mu} \leq -Xa\right)$$

$$= \sigma\varepsilon_2\mu \frac{-\theta\left(\frac{Xa}{\sigma}\right)}{1-\pi\left(\frac{Xa}{\sigma}\right)} = \sigma\varepsilon_2\mu\ \gamma_2 \quad \text{.....3.12}$$

θ and π are the typical normal distribution's probability density and cumulative distribution function, respectively. The ratio of θ and π assessed at Xa is known as the inverse Mills ratio γ_1 andγ_2. (Selectivity terms). The choice to commercialize and the outcome variable (per capita consumption expenditure) are correlated if the computed covariances $\sigma^2_{\varepsilon 1\mu}$ and $\sigma^2_{\varepsilon 2\mu}$are considerably different from 0 (Maddala, 1986). This indicates endogenous switching and a sample selectivity bias.

Finally, the study utilizes the ESR model coefficients to calculate the average treatment effects on the treated (ATT). This is done by making a comparison of the predicted per capita consumption expenditure of those who commercialize to the cases where they did not commercialize the rice that was produced. The *movestay* is executed and this is an evaluator that computes the overall log likelihood as well as its first and second derivatives. Weights and robust estimates are enabled, as well as the entire range of choices associated with Stata's maximum likelihood processes.

The estimated per capita consumption expenditure of commercialized households and non-commercialized households can be put in the following form.

$E[Y_{i1}|D = 1]$=$X_{i1}\beta + \theta_{u1}\delta_{i1}$…….3.13

$E[Y_{i1}|D = 1]$=$X_{i2}\beta + \theta_{u2}\delta_{i2}$…….....3.14

Taking the differences of equation 3.13 and 3.14, we therefore obtain the ATT for both households that commercialized rice and those that did no commercialize rice and this is represented below

ATT = $E[Y_{i1}|D = 1] - E[Y_{i2}|D = 1]$=$X_i(B_{i1} - B_{i2}) + \delta_{i1}(\theta_{u1} - \theta_{u2})$…...3.15

Hypothesized Variables

Table 3.2 presents description and the measurement of variables used in the ESR.

Table 3. 2: ESR Hypothesized Variables

Variable	Description	Measurement	Equation Type
Dependent Variables			
	Sold Rice	Dummy: 1=if household sold rice, 0=Otherwise	TRT
	Per Capita Consumption Expenditure	Count=Ghana Cedis (GHS)	OUT
Independent (Explanatory) Variables			
X_1	Age	Count=Years of Household Head	OUT/TRT
X_2	Sex	Dummy=1 if Male, 0= if Female	OUT/TRT
X_3	Farm Size	Count=Size of farm cultivated in Acres	OUT/TRT
X_4	Education	Count: Number of years of schooling of HH head	OUT/TRT
X_5	Rice Experience	Count: Years household have cultivated rice	OUT/TRT
X_6	HH Size	Count=Total number of members in the household	OUT/TRT
X_7	Labour	Count=Total number of people who worked on the farm	OUT/TRT
X_8	Livestock Owned	Count=Total number of livestock owned by Household	OUT/TRT
X_9	Credit Access	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{10}	Tv Owned	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{11}	Extension Contact	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{12}	FBO membership	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{13}	Owned Radio	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{14}	Owned Motorbike	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_{15}	Quantity of Mobile Phone	Count=Total number of mobile phone owned by household	OUT/TRT
X_{16}	Distance from Home to Market	Count=Distance in Km from home to the nearest market place	TRT
X_{17}	Motorable Roads	Dummy=1 if Yes, 0 Otherwise	TRT
X_{18}	Access to Improved Seeds	Dummy=1 if Yes, 0 Otherwise	TRT

Type of Equation= **TRT** (Treatment Equation) **OUT** =(Outcome Equation)

3.7.5 The impact of rice commercialization on farm household income.

Impact studies seek to determine the average effect of participation in a program (treatment). Drawing an inference regarding the result that would have been seen for the treated ('treatment group') if they had not been treated ('control group') is required for this. The capacity to produce a control group with the same distribution of features as the treatment group is the primary benefit of experimental tests (over non-experimental approaches). The treatment effect may be estimated in this instance as the differential in average outcomes. Participants in non-experimental research, on the other hand, typically self-select into treatment groups. The treated and controls differ not just in terms of their involvement status, but also in a variety of other ways.

Matching is a general non-experimental assessment approach that may be used to determine the average effect of the participation in a particular programme which in this case is commercialization. This technique compares program participants' results to those of matched non-participants, where matches are chosen based on similarities in observed features. Assume there are two sets of farmers, $P = 0/1$, where 1 (0) signifies farms that did (did not) engage in a program. Y_i^1 represents the result (farm performance) conditional on participation ($P = 1$), while Y_i^0 represents the outcome conditional on non-participation ($P = 0$).

If farms randomly commercialize, the causative effect of commercialization on farmers' income might be assessed by comparing the difference in income levels between participants and participants. In reality, commercialization is not assigned at random. Rather, it is a mechanism of' self-selection' by farmers. A collection of socioeconomic variables determines whether or not a farmer commercializes rice.

Socioeconomic factors influence commercialization, which may have a direct effect on farmer's well-being (or incomes, in this case). If commercialization has a positive link with income, it is difficult to determine whether the commercialization enhances farmer well-being or whether better-off farmers are more likely to commercialize.

Propensity Score Matching (PSM) is typically utilized for two main functions: 1) generating counterfactuals and 2) determining treatment effects. The PSM estimator contrasts the variation in the outcome of interest between participants and non-participants, depending on a set of observable parameters for both groups, when used to determine the treatment effect. To overcome selection bias, PSM makes key assumptions. The first assumption is conditional independence (also known as non-confoundedness), which states that prospective outcomes/impacts must be independent of how program participation is assigned (Rosenbaum & Rubin, 1983). This assumption suggests that selection is purely dependent on observables, implying that participation and outcome variables are seen concurrently.

The second assumption is the common support assumption, which states that economic agents with identical features should be equally likely to be participants or non-participants (i.e., they have equal chances of falling into either group). Even though a parametric regression model is utilized to determine propensity score in the first phase using a probit or a logit models, using Propensity Score Matching to calculate casual effect is deemed nonparametric. In contrast to regression models, which must meet specified criteria and requirements such as linearity, normally distributed error term, and interactions assumptions, propensity matching is not constrained by assumptions. As a consequence, the causative effects predicted by

regression models might vary significantly depending on the model's parameters and assumptions. As a result, employing the PSM to compute the causal impact is less prone to model assumptions being violated.

This method of PSM was chosen because of the numerous benefits it gives over other models. Due to the fact that the program lacks experimental farmers to serve as the control group, PSM is an acceptable non-experimental approach for this investigation. This PSM technique was chosen because of the various advantages it has over other techniques. PSM is a suitable non-experimental technique for this inquiry because the program lacks experimental farmers to serve as the control group. PSM approach may be useful in circumstances where logistic and probit regression is inadequate, such as when the analysis involves uncommon occurrences (outcomes) and several confounders, due to its unique features and capacity to produce a "quasi-randomized" experiment (Ali et al., 2019) The ability to compress multiple confounders into a single score (covariate) might avoid the problem of an unstable model and erroneous estimations caused by the presence of too many variables. Moreover, the PSM approach may be used to supplement and validate data acquired by other methods such as logistic regression (Li, 2013). Collapsing factors into a single score enables for the inclusion of potential confounders that would otherwise be impossible to incorporate and may increase statistical efficiency. This PSM method was selected because of the various advantages it has over other techniques. PSM is a suitable non-experimental technique for this inquiry because the program lacks experimental farmers to serve as the control group. The PSM method's main technique is to match observations of participants and non-participants based on their expected proclivity to adopt a superior technology (Marchenko & Genton, 2012; Wooldridge, 2003). The key feature of the matching

technique is the development of randomized experiment conditions in order to analyse a causal impact as in a controlled experiment.

The matching approach has lately gained prominence as an assessment tool and in this case assessing the impact of commercialization on household income levels. It presumes that selection can be described solely in terms of observable characteristics. In theory, the procedure is straightforward to implement. A matched participant from the non-treatment group is located for each member in the treatment group. The match is determined through observable qualities. It is necessary to match each individual in the therapy group with another individual who has comparable features. The average difference in outcomes between the treated and non-treated groups is then used to compute the mean impact of therapy. Unlike PSM, which can only estimate treatment effects when there is support for the treated people among the non-treated population, other experimental approaches guarantees that there is widespread support throughout the whole sample. These factors clearly place PSM ahead of experimental approaches. Using the framework of Rosenbaum & Rubin (1983), the propensity score can be estimated as $PX = P(G_i = 1/X)$. Furthermore, $Y_{1i.}$, $Y_{2i.}$ and G/X are outcomes independent of commercialisation (X) which implies $E\left(\frac{Y_{2i}}{G} = 1,\ P(X)\right) = E\left(\frac{Y_{2i}}{G} = 0,\ P(X)\right) 0 < P(X) < 1$

The PSM method pairs each household that have commercialized with a "similar" non-participant and calculates the treatment effect as the average difference in result between the matched participants and non-participants. The PSM estimator examines how a household's income level would have changed if the market participant households had opted not to commercialize rice.

To address the possible bias, PSM limits the comparison of outcomes to households with similar observable characteristics, eliminating the bias that would otherwise emerge if the two groups were systematically different (Li, 2013). As a result, PSM generates similar counterfactual households for market participants and matches them based on observable characteristics, decreasing bias related to observables. Moreover, PSM presumes that after households are matched on observables, there is no systematic variation in unobservable characteristics between participants and non-participants (Heckman & Navarro-Lozano, 2004). The mean impact of treatment on the treated is the most commonly used assessment parameter of interest which is as follows

$$ATT = \{E(Y_{1i}{-}Y_{2i} \,/\, G = 1,\ P(X) - E(Y_{1i}{-}Y_{2i} \,/\, G = 0,\ P(X))\} \ldots\ldots\ldots 3.16$$

It addresses the issue of "How much income did farm households that commercialized rice benefit compared to how much income they would have gotten hadn't they commercialize.

Using (Rosenbaum & Rubin, 1983) framework, the definition of the 'treatment effect' is the difference in household income in the two states of the world namely commercial (G=1) and non-commercial (G=0). The average treatment effect (ATE) is regarded as the treatment effect estimated across all the households.

$$ATE = Y_i(1) - Y_i(0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.17$$

In using non-experimental data, a challenge is existent since only one of the states of commercialization is observed; that is, for each household, either $Y_i(1)$ or $Y_i(0)$is observed, but not both. The income level obtained by participants (households who commercialized rice) if they did not commercialize cannot be determined. The assessment of treatment effects in the absence of information on the counter-factual (what would have occurred) offers an empirical issue known as the problem of filling

in missing data on the counter-factual (Rosenbaum & Rubin, 1983) The difficulty is that we can only see yield (Y_i) for farm households who commercialized. The challenge of missing data occurs because it is impossible to quantify the Income levels of individual farm households at any one time (Income for participants versus income for non-participants) As each household has either commercialized rice or not, and so a rice farmer cannot be both (participant and non-participant at the same time).

As a result, it is more convenient to express the ATE as

$$ATE = P[E(Y_1/G = 1) - E(Y_0/G = 1)] + (1 - P).[E(Y_1/G = 0) - E(Y_0/G = 0)]\ldots.3.18$$

In this equation, P is defined as the likelihood of getting a farm household that commercializes. The weighted average of commercialization (treatment) effect for participants and non-participants is used in Equation (3.18) to calculate the ATE for the entire sample. Both counterfactual well-beings, $E(Y_0/G = 1)$ and $E(Y_1/G = 1)$ are included for the estimation of the ATE.

Nearest Neighbour Matching

A statistical method called Nearest Neighbour Matching (NNM) is used in observational research to match each treated unit with one or more untreated units according to how closely their observable features match, therefore establishing a balanced comparison group. When randomized control trials are impractical and researchers want to reduce selection bias in treatment effect estimation, this approach is very helpful (Szekér & Vathy-Fogarassy, 2021). NNM's main goal is to lessen the influence of confounding factors such that the treatment and control groups are similar in terms of important observable traits. For every treated unit, a set of potential untreated units is identified, and the nearest match is chosen using a

predetermined distance metric. This procedure is known as nearest neighbour matching. This distance measure measures how different the units are from one another while accounting for factors like socioeconomic status, demography, and other pertinent characteristics. As further stated by Szekér & Vathy-Fogarassy (2021), the closest match is chosen to approximate a counterfactual scenario in which the treated unit did not receive the intervention, hence assisting in the creation of a balanced comparison group and enhancing the accuracy of causal inference. This technique randomly organizes the treatment and control cases, then chooses the first treatment and finds the control with the closest propensity score (two for 2 to 1 matching).

Nearest Neighbour matching of Commercialization treatment (those who commercialized) and control (those who did no commercialize) matching households that commercialized and seeking for a non-commercialized rice farm household with the nearest in terms of propensity score (the Nearest Neighbour). This method can be used with or without substitution while matching. With regards of match without replacements, non-participants can only be paired with participants once. When every household in the participants category is matched with a non-participant, the gap in income here between participants and the matched non-participants is computed. ATT is therefore calculated by finding the average of the estimated income differences.

Notwithstanding its effectiveness, Nearest Neighbour Matching is not without its constraints. The approach is primarily predicated on the idea that the observable variables included in matching sufficiently account for the unobservable traits that might affect treatment assignment. Assessing the impact of any hidden biases requires the use of robustness tests and sensitivity analysis. Furthermore, the

availability and quality of data are critical to the success of NNM as missing or erroneous information might cause problems with the matching process. Nearest Neighbour Matching is a useful technique for mitigating selection bias in observational research and is a workable method for determining causal effects in circumstances when putting experimental designs into practice is difficult.

Table 3.3 presents description and the measurement of variables used in the propensity Score Matching (PSM).

Table 3. 3: PSM Hypothesized Variables

Variable	Description	Measurement	Equation Type
Dependent Variables			
	Sold Rice	Dummy: 1=if household sold rice, 0=Otherwise	TRT
	Household Income	Count=Ghana Cedis (GHS)	OUT
Independent (Explanatory) Variables			
X_1	Age	Count=Age (Years) of Household Head	TRT
X_2	Rice Experience	Count: Years household have cultivated rice	OUT/TRT
X_3	Credit Access	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_4	Extension Contact	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_5	Owned Radio	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_6	Motorable Roads	Dummy=1 if Yes, 0 Otherwise	OUT/TRT
X_7	Remittances and Non-farm Income	Dummy=1 if Yes, 0 Otherwise	OUT/TRT

3.8 The role of agricultural support services on crop commercialization in Northern Ghana.

Descriptive measurement models that can be used in effectively analysing the role of agricultural support services in crop commercialization in Northern Ghana include the Descriptive Statistics Model. This involves the summarization and organization of data for proper distribution, centrality, and variability of major

variables. Measurements in this model include mean, median, mode, standard deviation, and range. Descriptive statistics will aid researchers in giving a general overview of the level of crop commercialization, the extent of support services available, and the relationship between these services and the commercialization outcome. Since this approach can very effectively display patterns and trends in data, it should be able to clearly indicate the current state of agricultural support services and the kind of effect they are rendering.

An approach that can be used is the Comparative Analysis Model, which considers a comparison among different groups or categories in the data. For instance, levels of commercialization of crops can be compared between farmers who get varying kinds or intensity levels of support services such as extension services, financial assistance, or access to agricultural inputs. Such a model could avail themselves of tools like cross-tabulations and Chi-square tests in the testing of the relationship between categorical variables, thereby bringing out how certain subcategories of these support services contribute to these varying levels of commercialization. Through comparative analysis, it will be identified which of these services are most effective in promoting crop commercialization and can help inform policy decisions that enhance agricultural productivity.

3.8.1 Pearson's Chi Square

Pearson's Chi-Square Test is the statistical method used in testing whether there is a significant relationship between two categorical variables. This principally applies to social science and agricultural sciences, among other fields, for testing hypotheses on the relationships between variables. This test compares the observed frequencies in each of the categories of the contingency table against the expected frequencies,

which are based on a consideration of the supposition of the variables being independent. The statistic calculation for the Chi-Square statistic uses this formula:

$$X^2 = \sum \frac{(O_{i-E_i})^2}{E_i} \text{.....3.19}$$

where O_i represents the observed frequency and E_i That is the expected frequency.

A high Chi-Square value indicates that there is a larger difference between observed and expected frequencies, which might indicate an association of variables. Several literatures have rather well expounded and validated the Pearson's Chi-Square test. Robustness of Chi-Square test concerning the execution process for large data-sets and simplicity in interpretation gave it wide popularity to the researchers for visualization of tentative exploratory analysis of categorical data.

However, some assumptions and limitations come with the application of Pearson's Chi-Square test. According to Lugo-Armenta et al. (2021), the test assumes that: the data are randomly sampled, and that the expected frequency in each cell of the contingency table is at least 5 to ensure the validity of the test. If these assumptions are violated, the results of this test may not be reliable. Furthermore, this Chi-Square test does not provide any information on the strength or direction of the relationship but simply that there is some form of association. Despite these limitations, Pearson's Chi-Square test forms the basis for categorical data analysis, providing a basis for further analysis and guiding the researcher in testing hypotheses and decision-making processes.

On the role of agricultural support services in crop commercialization in Northern Ghana, Pearson's Chi-Square analysis is better equipped than other descriptive statistics, in the sense that it can be used to test for independence between two

categorical variables, such as the types of agricultural support services and levels of crop commercialization. In contrast to descriptive statistics, which only describe data, Chi-Square analyses can determine if there is a statistically significant relationship between variables. This is particularly important in agricultural research, where the relationships of support services to commercialization outcomes bear on the design of policies and interventions.

A powerful aspect of Pearson's Chi-Square is its flexibility in dealing with large and complex data sets. Studies in agriculture often need to account for different types of support services, such as extension services or financial aid, or access to inputs, coupled with different levels of commercialization among crops and different farmer groups. Chi-Square testing can accommodate these multiple categories and deliver a comprehensive analysis regarding data handed over to it. It helps the research worker contrast the observed frequencies of commercialization for crops across the various categories of support services with the expected frequencies, to establish significant associations. According to Franke et al. (2012), the Chi-Square test is robust in the analysis of large contingency tables; hence, it's a very good tool in the exploration of the complex nature of agricultural support and its relation to commercialization.

The Chi-Square is using Pearson's Chi-Square analysis, which can be easily interpreted for a general audience, other researchers from different areas of research, and stakeholders' Conclusive evidence on whether any association between the variables comes from the results of the Chi-Square test, in a typical Chi-Square statistic format and a p-value. This simplicity is, again, an advantage in agricultural

research, where the findings should fluently flow to policymakers, extension officers, and farmers who may not have advanced statistical training.

To undertake Pearson's Chi-Square to determine the effect of various agriculture support services on crop commercialization, the model specification entails determining the product between a dummy variable, that is, sale of rice (1 = Sold Rice, 0 = Did Not Sell Rice) and several variables representing various types of agricultural support services. The independent variables include: Having Credit Support (Yes=1; No=0), Remittance received and Non-farm Income (Yes=1; No=0), Agric Training Services (Yes=1; No=0), Access to Subsidized Fertilizer (Yes=1; No=0), Access to Improved Seeds (Yes=1; No=0) and Support from Research Center (Yes=1; No=0). Next, the Pearson's Chi-Square test is used in the analysis of each of these categorical variables to identify any relationship between the availability of these support services and the probability of the household involved in rice selling. The measure establishes observed frequency of households selling rice with expected frequencies based on the null hypothesis to reveal the pattern of the relationship between the variables and the Chi-Square value to determine the strength and significance of these associations.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The results and the discussion of the findings of the study are presented in this chapter. The results and discussion are based on the data collected from 420 smallholder rice farm households. The chapter has five sections that addresses all the objectives of the study. The first section (4.2) looks at the socio-economic characteristics of the respondents. The second section (4.3) entails the determinants of rice commercialization in Northern Ghana, the third section (4.4) is the impact of commercialization on per capita consumption expenditure, the fourth (4.5) section is the impact of commercialization on household income and the fifth section (4.6) looks at the role of agricultural support services on crop commercialization in Northern Ghana.

4.2 Demographic Characteristics of Farm Households

The descriptive statistics from the data collected are presented in this section. The foundation of quantitative data analysis is descriptive findings and it provides the data summaries across observations. Table 4.1 presents descriptives of the demographic characteristics of farm households

4.2.1 Sex Distribution of Respondent

The study results revealed male dominated respondents. Majority of the household heads from the results was male. 396 respondents making 94.3% of the respondents were male whiles 24 respondents representing 5.71% of the respondents were female. This result reflects the situation in Northern Ghana where households are largely male headed. In view of commercialization, male household heads are much

more likely to effectively allocate resources than the female household heads (McCarthy & Sun, 2009)

4.2.2 Age Distribution of Respondents

The results of the study revealed that the average age of 41 years with the ages ranging from 18 being the minimum age of the respondents to 78 being the maximum age of the respondents. The average age of the respondents gives the indication that the majority of the rice farmers in that age category are in the economically active age brackets. This suggests that the farmer population is youthful, and it could be deduced that more younger farmers are venturing into the agricultural value chain. From the result, the age of respondents depicts that there is therefore a shift towards the youth engaging in farming and its allied activities including processing, commercialization among many others as supported by Akrong et al. (2020).Young farmers are therefore likely to engage in the commercialization value chain for a long time as compared to older farmers (Akrong et al., 2020)

4.2.3 Education of Respondents

The average number of years of schooling of the respondents is 2 years. This low level of the average years spent in school by the household head signifies that, the educational level of the household heads has been low. From the study, 321 respondents representing 76.43% of the household heads did not have formal education. Furthermore, 18.10% of the respondents had primary to secondary education with 3.75% of the household heads having technical education. Only 1.19% of the household heads had university education. In effect, the farmer population of the study have been non formal. It is expected that, the level of

education of household heads has the propensity to influence commercialization both positively and negatively. It is expected that educated household heads will participate in other income generating activities and education can also enhance knowledge and skill in the commercialization value chain (Wiredu et al., 2013)

4.2.4 Rice Production Experience of Respondents

Rice production experience indicates the number of years the household has been into rice cultivation. The average experience of the households according to the findings is 15 years. Averagely, farm households in the study area have been into rice farming for 15 years with the minimum years of rice farming being 4 years and the maximum years being 48 years. The results therefore signify that the farm households are fairly experienced in the cultivation and commercialization of rice. It is therefore expected that households with much experience in rice cultivation will have the ability to produce and market effectively.

4.2.5 Farm Size of Respondents

The average farm size is 10.115 acres. The minimum rice plot owned by a farmer is 3 acres whiles the maximum size of plot owned by a farmer is 26 acres. Farms owned by smallholders can range in size based on location and production methods.

Due to this, smallholder farmers are unlikely to practice large scale commercial farming due to their small piece of land and limited resources. Smallholders grow crops in parcels ranging in size from less than one hectare (2.47acres) to about 10 hectares (24.7 acres) (Kadapatti & Bagalkoti, 2014).

4.2.6 Household Asset Ownership of Respondents

From the results, the ownership of radio has a mean of 0.793, which implies that a sizable percentage of farm households in the sample own radios on average. The

standard deviation of 0.406 indicates that radio ownership varies to some extent among the rice farm households. In this regard, some farm households may have extremely high or very low radio ownership, as indicated by the values' possible unequal distribution around the mean.

The ownership of mobile phones indicated that a significant proportion (97.6%) of the rice farm households own a mobile phone on average, as per the mean of 0.976. The low standard deviation of 0.153 in comparison shows that farm households do not vary much in terms of their possession of mobile phones. This is further shown by the fact that most of the households seem to be at a range close to the average, hence a high degree of homogeneity in mobile phone ownership. According to our findings, the vast majority of farm households in the sample are mobile phone owners, and there is little difference in phone ownership amongst the households. With the ownership of television, majority of the respondents owned television sets. Given the mean of 0.705 of the respondents, it indicates that about 70.5% of farm households own a television. The standard deviation of 0.457 in this case shows there is some level of variation in owning a television among farm households, which may be due to various factors affecting the households other than owning a television.

The ownership of motorcycle has a mean of 0.695, which shows that, on average, 69.5% of the farm households are motorcycle owners. Furthermore, the ownership of motorcycle by the farm households has a standard deviation of 0.461 which suggests that farm households' motorcycle ownership is distributed evenly. Livestock ownership has also been an independent variable in the study. With regards to this, the ownership of livestock had a mean of 0.831 which shows that

about 83.1 % of the farm households in the study are livestock owners on average. Given that the variable is binary, the majority of farm households are livestock owners.

4.2.7 Household Labour of Respondents

In view of the labour on the household rice farms, in terms of labour days, the average of 38.964 indicates that workers on the rice farm put in around 38 days of work on average. Given this, a standard deviation of 8.928 indicates that there is an estimated 8-day variation in the total number of days that individuals worked on the rice field around the average days worked.

4.2.8 Extension Contact

The results of the study revealed that the average number of farm households with extension contact as per the mean of 0.281, is 28%. The degree of variability in the data is indicated by the standard deviation, which is 0.450. In this context, the 0.45 standard deviation is quite large, indicating a high level of variation in farm households' frequency of duration of contact with the extension agents.

4.2.9 Credit Access

The average of 0.838 indicates that, among the farm households in the sample, a sizable percentage (83.8%) had access to credit on average. At 0.369, the standard deviation is rather mild. It demonstrates that there is still significant variation across farm households even when the mean points to a high frequency of loan access overall. Some people could have more or less credit available to them than others.

4.2.10 Use of Improved Seeds

Based on the data in the sample, it can be inferred that 76.4% of farm households utilize improved seeds on average (mean of 0.764). This is a comparatively high

percentage, suggesting that households in the survey typically utilize improved seeds. The standard deviation of 0.425 shows the level by which respondents observations differ from the mean. In this regard, there is some level of variation in the adoption of better seeds by the farm households.

4.2.11 Membership of Farmer Based Organizations

The average percentage of farm households being members of FBOs, based on the mean of 0.467, is 46.7%. When you consider that the mean is about 0.467, the standard deviation of 0.499 is very large. This suggests that there is a significant degree of variation in agricultural households' FBO participation.

4.2.12 Distance from Home to Nearest Market

Based on the results, it can be inferred that farm households are, on average, 12.421 kilometres from the closest market, with a standard deviation of 5.751. With distances varying by about 5.751 km from the average distance, the standard deviation of 5.751 indicates that there may be some variation in this distance between the homes.

4.2.13 Availability of Motorable Roads

The availability of motorable roads has a mean of 0.607 indicating that, on average, a sizable percentage of farm households in the sample have access to motorized roadways. The average of 0.607 indicates that over half of the farm households from the result have access to motorable roads.

4.2.14 Quantity of Mobile Phones Owned by Households

Farm households own 4 mobile phones on average, as per the mean of 4.131. Given that the standard deviation is larger than the mean, it is possible that some households have a notably different number of mobile phones than the average.

Table 4. 1: Summary Statistics of Explanatory Variables (Continuous Variables)

Variable	Definition	Mean (Std.Dev.)
Age	Age of Respondents (Years)	41.640(10.842)
Sex	1 if farmer is male, 0 otherwise	0.943(0.232)
Education	Number of years Schooling(years)	2.436(4.664)
Rice Experience	The number of years of Rice farming experience	14.631(8.402)
Farm Size	Total Farm Size (Acres)	10.115(4.495)
HH Size	Total Household Size	14.105(7.733)
Quantity of Mobile Phones	Total Number of Mobile phones owned by households	4.131 (2.674)
Radio	1 if farmer owns a radio set, 0 otherwise	0.793 (0.406)
Mobile Phone	1 if farmer owns a mobile phone, 0 otherwise	0.976 (0.153)
Credit Access	1 if farmer had access to credit, 0 otherwise	0.838 (0.369)
Improved Seed	1 if farmer has access to improved seed, 0 otherwise	0.764 (0.425)
Motorable Road	1 if road to the farm is motorable, 0 otherwise	0.607 (0.489)
Own Livestock	1 if farmer owns livestock, 0 otherwise	0.831(0.375)
Labour	Total Number of days people worked on rice farm	38.964 (8.928)
Own TV	1 if farmer owns TV, 0 otherwise	0.705 (0.457)
Distance from Home to Nearest Market	Distance(km) from home to nearest market	12.421 (5.751)
Extension Contact	1 if farmer had extension contact,0 otherwise	0.281 (0.450)
FBO membership	1 if farmer belongs to an FBO, 0 otherwise	0.467 (0.499)
Own Motorbike	1 if farmer owns a motorbike, 0 otherwise	0.695 (0.461)

Source: Survey Data (2022)

Table 4. 2: Summary Statistics of Dependent Variables

Variable	Definition	Mean (Std.Dev.)
Total HH Income	Total Household Income(log)	8.424 (0.468)
Per Capita Expenditure	Household Per Capita Expenditure (Ghs)	157.806 (143.469)
Commercialization	Rice Sold (1 if sold rice, 0 otherwise)	0.836 (0.371)

Source: Survey Data (2022)

4.2.15 Total Household Income

Table 4.2 presents the total household income. The log of total household income is 8.424 on average based on the mean of 8.468. The log of household income of 8.424 means that averagely each household has a mean income level of Ghs8.424.

4.2.16 Per Capita Consumption Expenditure

Table 4.2 presents the per capita consumption expenditure. The average household consumption expenditure per capita in the results is Ghs 157.806 on average. This means that averagely a household's per capita consumption expenditure is GHs157.806 with the minimum per capita consumption expenditure in the household being Ghs16.786 and the maximum being Ghs1713.25.

4.2.17 Commercialization

Table 4.2 presents the measure of commercialization. From the results, a mean of 0.836 means that, on average, 83.6% of the farm households commercialized rice. Given the high mean (0.836), it appears that a sizable fraction of the households commercialized rice. This indicates that a fairly large proportion of the respondents are involved in commercial activity. The high mean indicates the extent and importance of rice commercialization to the surveyed households as a source of income

4.3 Determinants of Commercialization

4.3.1 Diverse Uses of Rice

This section presents the various uses of rice as revealed from the study. The diverse uses of rice in Northern Ghana have been categorized into Consumption, gifts, Stored and Sold.

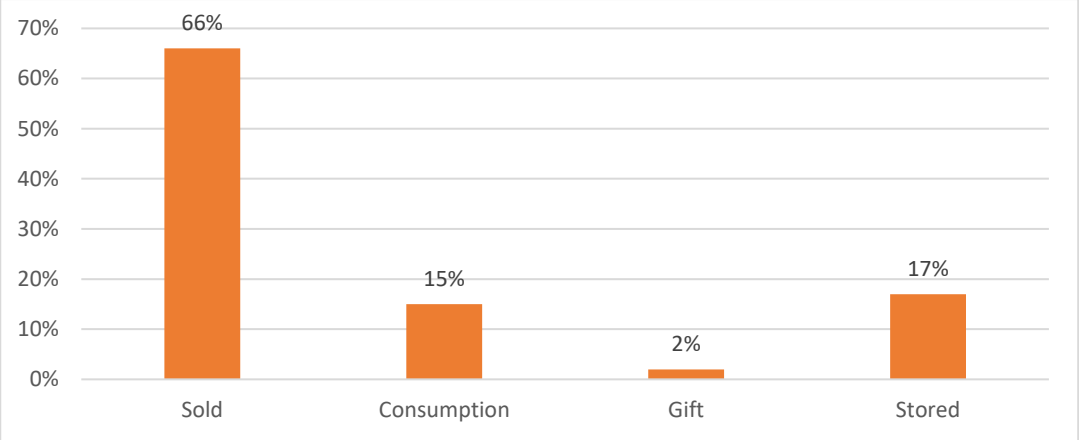

Figure 4. 1: Diverse Uses of Rice

Source: Survey Data (2022)

Figure 4.1 presents the diverse uses of rice produced by the smallholder farmers. With regards to the diversified uses of rice by the smallholder farmers, the smallholder farmers produce rice, of which 66% is sold, 15% is consumed, 2% is gifted, and 17% is stored. This distribution of rice produced offers important insights on the economic dynamics, and livelihood strategies of these farmers.

The large portion allocated to sales indicates the involvement in local or regional markets in Northern Ghana. It suggests that market-oriented agriculture is practiced by smallholder farmers who may be linked to larger supply networks (Abafita et al., 2016). As the results revealed that 66% is sold indicates the reality that many smallholder farmers depend on rice cultivation as a source of income. Selling a sizeable quantity of their crop enhances farmers' financial security and supports the local economies.

The percentage for consumption shows that much rice is produced for subsistence. This is mostly done by smallholder farmers who often grow crops for their own consumption. The 2% for gifts shows that probably there could be some social or cultural practices in Northern Ghana whereby farmers are giving out some of their

produce. Smallholder farmers may give gifts in their social networks as a means of reciprocating and showing kindness. This strengthens communal bonds and fosters a sense of being together. Smallholder farmers in Northern Ghana store part of the harvest as 17% of the produced rice is stored. Rice storage ensures food availability at constant levels during periods of shortage or unstable prices and protects against market uncertainties (Abebe et al., 2016).

4.3.2 Level of Commercialising

Table 4. 3: Level of Commercialization

	Frequency	Percentage
Subsistence (0-24.99%)	72	17.14
Surplus (25-50%)	8	1.90
Commercial (>50%)	340	80.95
Total	420	100

Source: Survey Data (2022)

The level of commercialization among rice-producing households was categorized into three distinct groups based on the share of rice output sold in the market: subsistence farmers who sell less than 25% (0–24.99%) of total rice production, thereby characterizing them as a production entity that mainly caters to household needs. Surplus producers, who would sell 25% to 50% of their outputs, would, therefore, represent a stage transitional to full commercialization. Finally, commercial farmers were those selling more than 50% of their production, representing full participation in the market. The classification highlights the level of market integration for rice farmers in the study area. Table 4.3 gives the various levels of commercialization. Producing enough food to fulfil the fundamental requirements of the farming household is the main characteristic of subsistence-oriented market participation. The 17.14% allocation suggests that a sizeable but non-dominant percentage of households in Northern Ghana cultivate rice mainly for

their own needs. Rather than growing excess for the market, farmers in this group are probably more concerned with providing for the dietary and food needs of their own home.

In view of the surplus oriented market participation, only a small percentage of farmers produce more than they need for immediate use, leaving some surplus available for market sale. The 1.90% suggests a very small percentage involved in excess production. This group of farmers might be able to sell some of their produce in addition to what is needed for their own use. But the low proportion implies that there aren't many farmers actively engaged in producing excess for the market. A large percentage (80.95) allocated to the commercial orientation signifies that most farmers in Northern Ghana place their emphasis on rice production mostly for the market, not subsistence. This, therefore, means there is strong commitment to producing rice focused on the market.

The high level of commercial orientation reveals a strong integration of agriculture into the market systems. This group of farmers probably produces not to meet the needs of their households but to earn income through selling outputs on local and regional markets. The shift to more commercial orientation underlines connection and market access. Most of the farmers who market their produce would probably have access to markets, a transport network, and market information that would enable active involvement in commercial agriculture (Martey, 2014).

4.3.3 Factors Determining the Commercialization of Rice in Northern Ghana

This section presents the results on the determinants of rice commercialization in Northern Ghana and brings to the fore the most important factors influencing farmers' participation in market-oriented rice production. The transformation from

subsistence farming to commercial agriculture are influenced by a set of socio-economic and institutional variables affecting farmers' ability to produce and sell rice beyond household consumption. The probit results in table 4.4 presents the determinants of rice commercialization.

Table 4. 4: Determinants of Rice Commercialization

Variables	Probit Coefficients	Marginal Effects (dy/dx)
	Coefficient (Std. err)	**Coefficient (Std. errr)**
Constant	0.834(1.303)	
Age	**0.0314*(0.0177)**	**0.003***(0.001)**
Sex	0.496(0.507)	0.042(0.038)
Farm Size	0.076(0.051)	0.006(0.005)
Education	0.002(0.041)	0.001(0.004)
Rice Experience	**-0.070**(0.029)**	**-0.006(0.001)***
Household Size	**0.055*(0.029)**	**0.005*(0.003)**
Labour	**0.028**(0.120)**	**0.002**(0.001)**
Own Livestock	-0.403(0.305)	-0.034(0.028)
Credit Access	-0.191 (0.293)	-0.016(0.025)
Own Television	**0.768***(0.206)**	**0.066***(0.021)**
Extension Contact	**1.139**(0.293)**	**0.097**(0.048)**
FBO Membership	**0.536**(0.249)**	**0.046**(0.024)**
Own Radio	-0.072(0.238)	-0.006(0.020)
Quantiy of Mobile Phone	0.006(0.094)	0.005(0.008)
Own motorbike	0.204(0.247)	0.017(0.20)
Distance from Home to Market	**-0.243*** (0.062)**	**-0.021***(0.002)**
Motorable Road	**1.160***(0.255)**	**0.099***(0.024)**
Access to Improved Seeds	0.263 (0.266)	0.022(0.023)
Observations.	**420**	

*****P<0.01, **P<0.05, *P<0.1.**

Robust standard errors in parenthesis

Source: Survey Data (2022)

From Table 4.4, age has been revealed to be a significant determinant of rice commercialization in Northern Ghana. With a standard error of 0.001, the estimated marginal effect of age on the probability of the outcome variable is 0.003. This

indicates that a one-year increase in age is linked to a 0.3 percentage rise in the likelihood of commercialization, holding all other factors constant. It means that older household heads are likely to commercialize rice than younger household heads based on the positive marginal effect.

The positive coefficient suggests that the probability of commercializing rice increases with age. Probably, it is due to the fact that rice farmers in Northern Ghana who are older, under the influence of increasing experience, expertise, or availability of complementary resources, are more likely to indulge in commercial activities.

The result of this study shows that, at the 1% level, the variable "Rice experience" which indicates the years of rice farming was determined to be statistically significant. More specifically, the marginal effect of experience in rice cultivation on the likelihood of commercialization, which is −0.006 and statistically significant at the 1% level. This implies that the likelihood of commercializing rice drops by 0.60% for every extra year of experience growing rice in the rural Northern Ghana. The results imply that, in this region, experience is related with a reduced probability of engaging in commercial rice farming, which counters to the wide assertion that more years of farming would lead to higher commercialization. Years of experience cultivating rice have a negative correlation with commercialization, which is consistent with some findings in the Ghanaian context. Farmers with more experience tend to be less risk-tolerant, favoring traditional sales techniques that offer prompt payment instead of the deferred payments associated with direct marketing to processors. Although this result was unexpected, other reasons may account for it. Experienced farmers are also less likely to be in a position to handle the logistic challenges involved in getting rice to the processors. The risk aversion

and preference for immediate cash flow may make even the most experienced farmers limit their level of commercialization (Ampadu-Ameyaw et al., 2017). They would rather sell to local traders or middlemen who provide instant payment than to large-scale processors who might give them a better price but would require delayed payments or logistical efforts to sell to them. Much of this risk aversion and demand for instant cash flow over possibly higher prices from processors greatly informs their marketing strategies (Donkor et al.,2021). The reluctance may affect yields and market participation.

On the other hand, there are reasons contrasting these results. According to Martey et al. (2012), experience may increase production and enhance farm management, hence increasing commercialization. They argue that experienced farmers possess substantial levels of information and experience that enhance their ability to adopt market-oriented farming practices. Besides, experienced farmers could have better market linkages and networks that would aid in commercialization.

The results from the study showed household size to be significant at 10%. The marginal effect for HH Size is 0.005. The positive coefficient indicated that for every additional person in the household, it would increase the probability of rice commercialization by 0.5%. Larger households could provide more labor and therefore facilitate more effective allocation to commercial activities. This means there is a slight positive correlation between household size and the likelihood of growing rice for commercial purposes. This could be due to many factors, including labor availability or economies of scale within large households. This is consistent with research conducted in Northern Ghana, where larger households may be able to devote more time and resources to marketing their rice output (Martey et al.,

2012c). According to Binswanger-Mkhize et al. (2016), larger households, under some conditions are less likely to be as successful at organizing labour or other resources, which may result in lower commercialization outcomes. This view holds that the relationship between household size and commercialization will be influenced by a variety of environmental factors.

From the findings, it is observed that, at a 10% significance level, the marginal effect of labor on the likelihood of rice commercialization is 0.002. This means that one-unit use of labor would raise the probability of rice commercialization by 0.2%. The positive effect implies that more labor availability to the farmers makes them produce more rice and engage in more commercial activities. This therefore implies that sufficient availability of labour is very instrumental in helping farmers to increase their level of production to meet the demand from consumers. This might suggest that households with larger labour supply are better suited to engage in commercialization because they are either more productive or have the capacity to oversee large farming operations. This result is supported by Vercillo (2020) which shows that households with more farm labourers typically attain higher levels of agricultural commercialization. According to the study, there is a positive correlation between higher crop yields and the capacity to devote enough labour to farming, which increases the possibility that excess produce will be accessible for commercialization. On the contrary, Chapoto et al. (2013) stated that crop commercialization may involve households with little agricultural labour but strategic access to resources to a larger extent. Conversely, Hagos & Geta (2016) concluded that though agricultural labour is a major factor in commercialization, several contextual factors like infrastructure, regulatory support, and market conditions shape the relationship between labour availability and commercialization.

Furthermore, households with less agricultural labour might make up for this by strategic planning at the markets or even by efficient management of available resources.

The findings showed that, the ownership of a television is one of the major determinants of smallholder rice commercialization. The marginal effect of owning a television on the probability of rice commercialization is positive and significant. Specifically, rice commercialization increases by 6.6% with TV ownership. It can be said that there is a higher probability to undertake rice commercial activities by farmers who have access to television. This could be attributed to the fact that they receive more market information, information on agricultural technologies and market trends affecting their decision-making process in selling rice. Supporting this finding comes from studies by Mango et al. (2014) that suggested that the ownership of communication mediums including radio sets, TV sets, mobile telephones facilitate commercialization through marketing information for farmers who have a favourable influence on the involvement in the output market. The existence of market information through these media would enhance the trust of farm households who are ready to commercialize. On the other hand, studies by Mittal (2012) might cast doubt on the idea that television ownership directly fuels the desire for commercialization among smallholder farmers. There is a contention that though television can provide the farmers with some commercialization related information, a number of contextual factors may reduce its impact in decision-making. In essence, access to television does not mean that farmers will apply knowledge appropriately if they have other challenges such as bad road infrastructure, illiteracy, or lack of funds.

Based on the marginal effects of extension contact on rice commercialization, for each additional contact with the extension officer, the probability of engaging in rice commercialization increases by 9.7% at 0.097. Therefore, farmers who frequently come into contact with extension officers are more likely to be engaged in rice commercialization. This could be as a result of improved knowledge, skills, and access to resources. It implies that farmers who frequently contact extension officers have better resources, information, and expertise to participate in commercial agriculture. The findings support other studies that highlight the effect of extension services along the entire agricultural value chain from production to commercialization. According to Danso-Abbeam et al. (2018), extension services provide farmers with information related to markets, crop management, and technical know-how that aids in making informed decisions. This could therefore mean that if commercialization is positively correlated with extension contact, it is worth noting that access to extension services improves smallholder farmers' capacity. Further aligning with the findings is that, extension services often expose farmers to new technology and best practices, hence enabling them to increase production and adopt more economically viable approaches. As corroborated by Chowa et al. (2013), farmers who regularly interact with extension agents are more likely to learn about cutting-edge agricultural practices, effective pest management plans, and effective irrigation techniques all of which raise the possibility of commercialization.

The membership of Farmer Based Organizations (FBOs) has been revealed from the findings to be a significant determinant of rice commercialization in Northern Ghana. The marginal effect of FBO membership on rice commercialization in Northern Ghana is 0.046 and is statistically significant at the 5 percent level. This

means that the probability of rice commercialization will increase by about 4.6% as a result of FBO membership. This finding is consistent with the assertion that FBOs can offer farmers the most important services, including access to markets, inputs, and information, which increase their commercialization of rice. The results are important in underlining that there is an advantage to collective action in agricultural communities through structures, especially in areas where individual farmers are otherwise unable to access resources or opportunities available to them as independent operators. The strong, positive, marginal effect of FBO membership on rice commercialization in Northern Ghana indicates that collective action through FBOs enhances farmers' ability to market their produce effectively. This finding is in line with Abdul-Rahaman & Abdulai (2020) who found that FBOs in Ghana very significantly improve farmers' access to critical farm inputs, agricultural extension services, and credit facilities that reinforce and shape productivity and commercialization. Particularly, this has been more so because the nature of most FBOs in Ghana usually facilitates bulk purchases and collective bargaining, hence reducing costs and improving market access for their members. This positive impact, as seen in the case of Northern Ghana, is because of the role FBOs play in training and education on modern farming techniques to raise the level of productivity and quality of produce and hence enhancing their marketability. Though there are noted effectiveness, some studies have presented the challenges of FBOs in Ghana. According to Salifu (2015), the success of FBOs in Ghana have not been uniform; there have been both internal and external constraints on its success. The internal factors, which could hamper the effectiveness of FBOs, are poor leadership, lack of transparency, and insufficient commitment from members. Externally, low market

access, poor infrastructure, and irregular government support can reduce the gains that are likely to be enjoyed from an FBO membership.

The smallholder farmers' distance from their homes to the market centre was significant at 1%. With the marginal effects the probability of rice commercialization is anticipated to drop by around 2.1 percent for every unit increase in distance from house to the market. The research found that it can be easier for farmers to commercialize rice if they are closer to market centres. The farmers who are close to market centres will find it easier compared to those who are farther away. This might be because those farmers closer to markets have better access to transport networks, information about markets, and customer reaches. Lowering transport obstacles may therefore help rice commercialization efforts. This further corroborates with the findings of Reardon & Timmer (2012) as they argue that proximity to markets is a key driver of commercialization, facilitating easier access to buyers, timely information on prices, and reduced transportation costs. They argue that farmers who are situated nearer to market centres have easier access to consumers, knowledge, and transportation infrastructure, allowing them to engage in more commercial agricultural activities.

A significant variable in determining commercialization of smallholder farmers is the motorable road connecting their homes to the market centres. The state or even accessibility of these roads could have impacts on farmers' capacity to transport commodities effectively, hence influencing their engagement in commercialization. The motorable roads linking their homes to the market centres have a great influence on the probability commercialization among the smallholder farmers. The state, condition and accessibility of these roads can influence the way in which farmers

pursue commercial activities and therefore their ability to move commodities in an efficient manner. Accessible and well-maintained motorable roads would offer smallholder farmers better prospects for commercialization. Research by Morgan (2019) and Owusu & İşcan (2021) are just two of studies that highlight the benefits of good road infrastructure for farmers' access to markets and ability to commercialize their products. Better roads will save transportation money, shorten time to markets and because producers can benefit from better market conditions, more business activity takes place. According to other studies, a lack of road infrastructure has devastating effects. For smallholder farmers in areas without motorable roads or where such roads are badly maintained, it is difficult to transport goods to market places. This may lead to delays, increased costs of transport, and possibly even post-harvest losses. Related studies (Pinstrup-Andersen & Shimokawa, 2006 ; Olukunle, 2013) emphasize how inadequate infrastructure of roads hinders successful marketing of agricultural commodities by farmers. Furthermore, the influence of motorable on rice commercialization is not uniform and may differ under other conditions. For instance, the construction of new roads can create chances for commercialization to rural areas with limited accessibility to markets. On the other hand, road building or improvement may have relatively lesser benefit where accessibility of markets is already good.

4.4 The impact of rice commercialization on per capita household consumption expenditure.

The impact of rice commercializing on household per capita consumption expenditure may however be varied. To this regard, rice commercialization may substantially improve the households' income. Higher yields and easier access to markets often bring increased income to farmers making the shift from subsistence

to commercial farming. This would thus have a positive impact on per capita consumption expenditure, and in that turn, the households will be able to afford more diversified and nutritious diet. However, it may change under various variables such as credit availability and market volatility. However, it may also have some negative aspects associated with it which may include sensitivity to market swings and economic disparity amongst the agricultural households.

4.4.1 Composition of Household Consumption Expenditure

Table 4. 5: Composition of Household Consumption Expenditure

Variable	Definition	Mean (Std. Dev.)
HH Food Cons. Exp	Household Food Consumption Expenditure (GHS)	241.5875(450.6291)
HH Non- Food Cons. Exp	Household Non-Food Consumption Expenditure (GHS)	1595.196(1379.359)

Source: Survey Data (2022)

Table 4.5, shows that the average monthly expenditure by rice-producing households in Northern Ghana on food items is 241.59 GHS. Their spending on food consumption seems to vary widely as revealed by the rather large standard deviation indicating how some of them may be spending far above or below the average. For non-food items, they spend an average of 1,595.20 GHS. The large standard deviation indicates that there could be high variance in spending for non-food consumption, which may be due to different spending habits among households. The difference between the averages of expenditure for food and non-food consumption shows the diversity in spending preferences between rice-growing households. A sufficient supply of food may be the top priority for certain households, while a greater portion of their money may go into non-food items. The result that households devote a larger share of their budget to non-food expenditures as their economic well-being improves is supported by studies by Regmi & Meade (2013)

who underscores this change as frequently linked to higher expectations for better living conditions, healthcare, and education. The results of this study align with the observed pattern of higher expenditure on non-food consumption. Furthermore, the larger standard deviation suggests a higher degree of variability in non-food consumption expenditure, which might suggest different spending habits among households. The observed discrepancy may be caused by certain households prioritizing investments in durable items, health care, or education.

4.4.2 Rice Commercialization and Per Capita Consumption Expenditure

This section presents the results of rice commercialization and its impact on household consumption per capita consumption expenditure. Analysis in this section considers household welfare, in per capita consumption expenditure terms and whether commercialization impacts household welfare. This section, estimates generated through use of an Endogenous Switching Regression (ESR) model. Maximum Likelihood Estimates (MLEs) included in the estimates have information about factors explaining household commercialization, and the Average Treatment Effect on the Treated (ATT), commercialization impact on household consumption per capita expenditure.

Table 4. 6 Maximum likelihood estimates of endogenous switching regression model

Variable	Selection	Participants	Non-Participants
	Coefficient (Std.err)	**Coeff (Std. Err)**	**Coeff (Std. Err)**
Constant	0.834 (1.303)	-38.667 (51.878)	**150.9** (67.18)**
Age	**0.0314* (0.0177)**	0.720 (0.642)	-0.887 (0.829)
Sex	0.496(0.507)	22.11 (25.622)	-17.529(18.286)
Farm Size	0.076(0.051)	**5.733***(1.644)**	-0.570 (2.841)
Education	0.002(0.0332)	**5.828**(2.419)**	-1.262(1.603)
Rice Experience	-0.070**(0.029)	-1.010(0.806)	1.760(1.575)
HH Size	**0.055*(0.029)**	**-11.515***(1.239)**	**-11.206***(3.117)**
Labour	**0.028**(0.012)**	0.257 (0.860)	-0.479(1.052)
Own Livestock	-0.403 (0.030)	**39.065**(14.531)**	**49.956**(21.350)**
Credit Access	-0.191 (0.293)	20.039(14.020)	7.995(25.691)
Own Tv	**0.768***(0.206)**	**27.216*(12.203)**	**47.513***(18.615)**
Extension. Contact	**1.139**(0.293)**	16.655(17.187)	-11.931(18.318)
FBO Membership.	**0.536** (0.249)**	**51.479***(15.162)**	11.927(27.694)
Own Radio	-0.072(0.238)	**43.468**(17.720)**	15.059(15.582)
Own motorbike	0.204(0.247)	**32.598**(12.878)**	**23.584*(17.121)**
Qnty of Mobile Phone	0.006(0.094)	3.297(2.929)	**11.524*(7.839)**
Distance from Home to Market	**-0.243*** (0.062)**		
Motorable Road	**1.160***(0.255)**		
Access to Improved Seeds	0.263 (0.266)		
$In_{\sigma 0}$			**4.055***(0.0856)**
$\rho_{\mu 0}$			-0.231 (0.237)
$In_{\sigma 1}$		**4.801***(0.0379)**	
$\rho_{\mu 1}$		-0.149(0.209)	
Log likelihood:	-2619.3418	351	69
LR test ind X^2(2):	**1.32**		
Obs.	420		

*****P<0.01, **P<0.05, *P<0.1.**

Robust standard errors in parenthesis

Source: Survey Data (2022)

Table 4.6 presents the ESR estimation results that examine the impact of rice commercialization on household per capita consumption expenditure among rice

farmers. As shown, at the 1% level of significance, the coefficient is given as 5.733, suggesting a positive relation between rice commercialization and farm size, offering significant insights on the economic dynamics of people in the area. The positive coefficient of 5.733 indicates that household per capita consumption expenditure increases proportionately to farm size among those involved in rice commercialization. This result is consistent and follows the economic theory. Large farms are often more productive and produce more revenues. Therefore, households that commercialize rice will probably be in a better financial position, which permits them to afford more expenditures on consumption. The results are consistent with previous literature welfare and agricultural commercialization (Reardon et al., 2009; Barrett et al., 2012). The significant effects of commercialization on income and livelihoods have been the subject of several studies. Reardon et al. (2009) highlights how commercialization may improve rural development and smallholder earnings. Barrett et al. (2012) finds evidence of a significant relationship between farm size and consumption expenditure, pointing to the relevance of agricultural productivity increases in reducing poverty.

The results also reveal that household consumption patterns and commercialization activities may be significantly influenced by education. Higher education tends to have a significantly favourable impact on household per capita consumption expenditure for those who engage in rice commercialization, as per the significant coefficient of educational level (5.828). This might be explained by the possibility that people with higher levels of education are better able to handle the dynamics of business operations, make wise judgments, and effectively manage resources. This result is consistent with existing literature that highlights how education may improve economic success. Higher education levels are linked to better income-

generating activities specifically access to credit (Dzadze et al., 2012). The human capital theory, which holds that education improves one's capacity to engage in economic activities, is compatible with the positive correlation shown between education and the effects of commercialization (Becker, 2009). While education is important, Rabbi et al. (2019) contend that it may not be the only factor that determines success in commercial endeavours. Other factor including market situations, socio-cultural dynamics, and resource accessibility could also be important. As such, it is important to take the larger socioeconomic background into account.

For participants, or those who commercialized rice, the coefficient of household size was found to be significant at 1%, with a coefficient of -11.515. Likewise, non-participants, or those who did not sell rice, had a significant household size at 1%, with a coefficient of -11.206. These results indicate that per capita expenditure in consumption is significantly influenced by household size; the larger the size of households, the lower their per capita consumption expenditures. The negative coefficients suggest per capita consumption expenditure decreases with household size. This aligns with Doss (2018) who stated the fact that larger households might find it more difficult to provide for everyone's basic needs, thereby reducing resources and consequently decreasing per capita consumption. On the other hand, larger households will benefit from economies of scale in some areas of consumption, although this may not be enough to offset the general decline in per capita expenditure. This is particularly for the rural setting of Northern Ghana where agricultural activities such as rice commercialization, influence household dynamics.

Ownership of television was also revealed to be a significant determinant of per capita consumption expenditure through commercialization of rice in Northern Ghana. First and foremost, the ownership of TVs has a significant relationship with participation in rice commercialization at 10%, with a coefficient of 27.216. This implies that television ownership and participation in rice commercialization are both positive in terms of per capita consumption expenditure of households. Television ownership from the findings is an indicator of better socio-economic status and availability of information which might result in higher levels of consumption. On the other hand, for those who do not participate in rice commercialization, the level of significance is at 1% level with a coefficient of television ownership of 47.513. With regards to rice commercialization, owning a television still has more significant positive impact on per capita consumption expenditure for a non-participant household. For non-participating households, there appears to be a strong correlation between television ownership and consumption, as indicated by the greater coefficient and lower standard error. These results are consistent with the body of research on the relationship between household consumption and media ownership. Donkoh (2020) in support of this has highlighted how mass media such as television can act as an avenue for exposure to external influences and information accessibility. The positive coefficients for both participants and non-participants support the assumption that television ownership positively impacts household consumption expenditure. This might be explained by how television shapes preferences, disseminates market information, and affects customer behaviour. It is important to consider that these findings may also ignite discussions about possible confounding variables and alternate theories. For instance, the link between the ownership of a television and consumption

expenditure may be bidirectional, meaning that more consumption raises the affordability of luxury goods like televisions.

The findings of the study reveal farmer-based organization membership as a significant determinant of rice commercialization among participants of rice commercialization. The coefficient of FBO membership among participants is 51.479, and it is significant at 1%. It is indicated that participants in the commercialization of rice had a positive effect on household per capita consumption expenditure as per the significant coefficient of FBO membership. This result supports the idea that, by giving farmers access to markets, relevant information, and collective bargaining power through farmer-based organizations play a critical role in advancing agricultural commercialization. The studies that back up this positive relationship highlights how FBOs may effectively participate in commercial agriculture operations to increase farmers' income and general well-being (Salifu et al., 2012). However, it is worth noting that, the positive association may not be universal, and some literature provides contrasting views. Rwelamira (2015) further argues that FBO effectiveness in commercialization processes depend on an organization's structure, governance mechanisms, and levels of external support. Some studies (Asante et al., 2011) have, however reported instances where FBOs experienced challenges in delivering the expected benefits and hence mixed outcomes in terms of improvements in income and consumption.

The ownership of radio has been significant from the findings of the study. Specifically, it was found that the coefficient of radio ownership for participants or those who commercialized was significant at 5%, with 43.468 as the coefficient. This result implies that radio ownership among those involved in the

commercialization of rice has a significant effect on household consumption expenditure per capita. The finding that participants in the rice commercialization had a positive and significant coefficient of radio ownership suggests that radio-based information access has a beneficial impact on household per capita consumption expenditure. This result is consistent with prior research that highlights the importance of information availability for rural development and agricultural decision-making. According to studies (Aker, 2011; Chhachhar et al., 2014) the value of communication channels such as radio in disseminating weather predictions, good farming practices and market information. Having better knowledge of the weather patterns and market dynamics, rice producers in Northern Ghana can make more strategic decisions about their commercial operations which may result in increased revenue and consumption expenditure. A number of factors can be attributed to the observed relationship between radio ownership and household consumption expenditure. Farmers may find it easier to obtain market pricing with the use of radios, thus helping them decide when and where to sell their commodities. Radio-broadcast agricultural extension programs can improve farmers' knowledge and skills, thus raising their income and production.

The ownership of motorbike has been revealed to be significant from the results. With a coefficient of 32.598, the study shows that the motorcycle ownership coefficient for participants or those who marketed is statistically significant at the 10% level. Similarly, with a coefficient of 23.584 for non-participants. The findings indicate that there exists a positive correlation between motorbike ownership and higher household per capita consumption expenditure among households involved in rice commercialization. This can be a sign of easier access to markets, more effective transportation, and potential sources of revenue. The significant effect of

motorcycle ownership on commercialization may have broader implications for poverty reduction and economic empowerment in northern Ghana. Motorcycle ownership could also facilitate the diversification of sources of income, aside from the easing of transport burdens for carrying agricultural products. The positive relation suggests that the higher levels of rice commercialization experienced by households possessing motorbikes translate into higher per capita consumption expenditure. This is in line with research by Addison et al. (2015) which underlines the importance of agricultural transportation systems in changing subsistence-oriented agriculture into commercial businesses and increasing household welfare and consumption expenditure. According to studies, improved access and infrastructure to transportation have impacts on rising income and consumption (Reardon & Timmer, 2012). It's interesting to see the significant relation for motorcycle ownership among non-participants. It might suggest that having a motorcycle is linked to higher household consumption expenditures even in the absence of rice commercialization. This can be the result of more accessible services or other sources of revenue.

The quantity of mobile phones owned by non-participants have been revealed to be significant at 10%. The coefficient of the quantity of mobile phones for non-participants or those not engaged in commercialization is statistically significant at the 10% level, with a coefficient of 11.524. Information and communication technology, more specifically mobile phones appear to be some of the key determinants of the commercialization patterns of households as reflected in the significant coefficient associated with the number of mobile phones for the non-participants. This result is also in line with literature demonstrating how mobile phones can have a very significant impact in rural development settings (Aker, 2010;

Muto & Yamano, 2009). Increased access to market information, weather forecasts and agricultural extension services through mobile phones could have a positive influence on farmers' decisions to commercialize. This positive coefficient could be an indication that most of the non-participating households are endowed with high number of mobile phones, hence better access to markets and information networks that influence decision-making processes in agriculture. This is consistent with research by Labonne & Chase (2009), which points out how ICT can improve rural lives and reduce inefficiencies in markets. The significant impact that, the mobile phone makes a difference for the non-participants means that, even with direct participation in commercialization of agriculture, the income diversification measures may benefit through access to information from mobile phones. The results support the claim made by Qiang et al. (2012) that mobile phones boost rural populations' economic resilience by giving them access to a variety of economic options outside of agriculture.

The endogenous switching regression model's correlation parameters are linked to the coefficients $\boldsymbol{\rho_{\mu 0}}$ and $\boldsymbol{\rho_{\mu 1}}$, which represent the correlation between the selection equation's unobservable individual-specific effects ($\boldsymbol{\mu}$) and the outcome equations for participants and non-participants, respectively. $\boldsymbol{\rho_{\mu 0}}$ and $\boldsymbol{\rho_{\mu 1}}$ in this instance are not statistically significant. The lack of statistically significant correlation between unobservable factors that influence the decision not to participate in rice commercialization and unobservable factors that influence the per capita consumption expenditure of the households of the non-participants is represented by the insignificance of $\boldsymbol{\rho_{\mu 1}}$. This suggests that, from the findings, there is no correlation between unobservable factors affecting consumption decisions and the unobserved factors that determine non-participation in commercialization.

Furthermore, the insignificance of $\boldsymbol{\rho_{\mu 0}}$ also indicates that there is no significant relationship between the unobservable factors that affect participants' decisions to be engaged in rice commercialization and the unobservable factors that impact their household per capita consumption expenditure. This suggests that there is no substantial correlation between the unobservable factors affecting participants' decisions to participate in commercialization and the unobservable features influencing their consumption decisions within the parameters of the model and the observed variables. The decision-making processes pertaining to involvement in rice commercialization and home consumption are rather independent in the current context, as indicated by the absence of statistical significance in both correlation factors.

From the results of the $\boldsymbol{In_{\sigma 1}}$, a higher absolute value of the $\boldsymbol{In_{\sigma 1}}$ indicates larger variation of the $\boldsymbol{In_{\sigma 1}}$, which implies that the variables that affect consumer expenditure differ considerably among rice-commercializing households. It can thus be explained by different farming methods, resource accessibility, or other socioeconomic issues. This variation may be as a result of various farming practices, the accessibility of resources, or other socioeconomic problems. With regards to the households not commercializing rice, where there is high heterogeneity in the unobservable factors influencing household per capita consumption expenditure, the coefficient $\boldsymbol{In_{\sigma 0}}$, 4.055 is statistically significant. The positive indication shows that the factors which affect consumption decisions are very different among non-participants. That may be caused by the heterogeneity due to variations in the size of land, the availability of credit, or some sociodemographic variables.

4.4.3 Average Treatment Effects of Commercialization on Household Per Capita Consumption Expenditure

This section presents the impact of rice commercialization on per capita household consumption expenditure on consumption using the Average Treatment Effect (ATE) approach. One of the drivers to improve households' well-being is commercialization as it increases income, which influences consumption. Households that have higher commercialization levels are expected to have improved access to food and other basic commodities that translate into improved living standards. By comparing commercializing and non-commercializing households, this section gives an idea of how much commercialization contributes to household welfare. The findings are reported and discussed in the following subsections.

Table 4. 7: Average Treatment Effects

Variable	Participants	Non-Participants	ATT	t-value
	Mean Outcome (*Per Capita Consumption Expenditure*)			
	162.798(4.315)	101.151(63.777)	**61.647**	**22.489*** **

Source: Survey Data (2022)

The ATT of commercialization on per capita consumption expenditure is presented in Table 4.7. For participants, the average per capita consumption expenditure is 162.798, but for non-participants, it is 101.151. According to this initial comparison, households involved in rice commercialization spend more per capita on consumption on average than those who do not. In the endogenous switching regression used for the analysis, the average treatment effect (ATT) of 61.647 with a t-value of 22.489 significant at 1% shows how rice commercialization affected

participants' household per capita consumption expenditure in comparison to non-participants. The statistically significant ATT of 61.647 indicates that households that participate in rice commercialization spend much more per capita than households that do not. This magnitude corresponds to the economic relevance of rice commercialization in the northern part of Ghana and indicates that rice commercialization has a positive effect on the welfare and standard of living for participant households in rice commercialization. Therefore, the positive ATT means rice commercialization brings a significant positive impact on the economic well-being of the households. It suggests further that the average per capita consumption expenditures of participating households are higher, hence more access to goods and services. This is corroborated by economic theory and studies such as Chapoto et al. (2013) and Martey (2014) have shown that improved living standards and diversification of sources of livelihoods could be achieved through commercialization of agricultural produce. With the high level of statistical significance, chances are that the effect observed was not as a result of chance. Compared with the traditional regression models, the model provides a more accurate assessment of the treatment effect by taking into consideration the endogeneity of the decision to commercialize rice.

4.5. The Impact of rice commercialization on farm household income

The extent to which rice commercialization has impacted on household income is one of the features of the agricultural and the economic growth of Northern Ghana. Rice is one of the major crops cultivated and owes much to food production in Northern Ghana and for that reason, rice is central to the livelihood of many people in the area. The commercialization of rice which is a shift from subsistence farming could have an effect on the dynamics of household income. Commercialization of

rice affects household income in a various way. The selling of surplus produce from the production of rice on one hand could lead to improvement in the household income. On the other hand, it also faces challenges related to technology, financing, and market access. The success of commercialization initiatives of rice depends on a number of variables: market conditions, government policy, and farmers' adaptability toward key changes in the needs of the major market segments.

4.5.1 Income Patterns among Households

This section presents the distribution of household income in various income groups among rice producing households in Northern Ghana. In assessing the impact of rice commercialization on household income, the distribution becomes an important component.

Table 4. 8: Average Annual Household Income

INCOME(GHS)	FREQUENCY	PERCENTAGE
300-1000	1	0.24
1001-5000	274	65.24
5001-10000	116	27.62
10001-15000	22	5.24
15000+	7	1.64
Total	**420**	**100.00**

Source: Survey Data (2022)

From the results, it is revealed that households that fall between the income group GHS 1001–GHS5000 forms the majority with 65.24% of the households falling in this income range. This suggests that a significant number of rice-producing households in Northern Ghana fall within the middle-income category. A smaller proportion of the households however earn less than GHS 1000(0.24%), between GHS 5001 and GHS 10000 (27.62%) and above GHS 15000 (1.64%). There is however a concentration of households within the GHS 1001-5000 category. Since

most of the rice producing households fall within the GHS 1001–GHS 5000 income bracket, this could increase the chances of rice commercialization having a positive effect on household incomes. Commercialization refers to the act of selling surplus food in the market to enable farmers to earn an additional income. This notion that farmers can improve their income levels by practicing market-led agriculture is corroborated by Tirkaso (2013).

The income distribution patterns reveal the economic heterogeneity among rice producing households. There are different categories of income reflective of different economic well-being as some households earn more than other households. This variability aligns with literature on agricultural economics that underscores the differences between farm households and their responsiveness to market forces (Alemayehu et al., 2022). The results show a high concentration of households within the GHS 1001– GHS 5000 income bracket. It is therefore imperative to explore into detail, the factors that contribute to such a pattern. This could be as a result to some structural constrains inherent in the rice commercialization process. For instance, some rice-product households may not be able to move into higher-income groups due to limited market accessibility such that they do not have the chance to sell rice produce in more lucrative markets. Secondly, resource endowment and farming practices vary across households which may affect their ability to maximize profits. It is the dynamics of participation in the markets or perhaps what goes into this accessibility of the markets and distribution of resources among households that sets the interesting dimensions of these gaps. This distribution of households across different income groups raises questions about potential input constraints that may limit some households' ability to realize higher incomes from rice commercialization (Barrett, 2010).

Accessibility to quality inputs, such as better seeds, fertilizers and modern farming technologies can greatly influence productivity and hence income. In this regard, households in situations where it is hard to access these inputs may face challenges competing in the market, hence resulting in the concentration within the GHS 1001-GHS 5000 income bracket. Interventions targeting a reduction of technological gaps and input constraints with active extension service would be relevant. Another dimension that can be added to this would be the socioeconomic gaps that might be leading to this kind of income distribution. Education, access to credit, land ownership, and other variables personal to households have an effect on their ability to engage in rice commercialization effectively.

4.5.2 Factors Determining Rice Commercialization

This section presents the findings of the logistic regression, which form the basis of the propensity score matching process, provide light on the variables influencing household income in the context of Northern Ghana's commercialization of rice. PSM is applied to analyse the impact of commercialization on household income because it tends to reduce the problem of selection bias through the creation of a comparable control group. Unlike ESR, which controls for endogeneity in a model structure, PSM ensures that matching between treated and control households is done based on observed characteristics and hence minimizes the problem of confounding. ESR assumes a certain functional form and requires strong instruments, which are not always available. PSM is a non-parametric approach that first balances the observable covariates and then estimates the treatment effects, complementing ESR in order to ensure robust causal inference. Combining both methods enhances result validity and robustness

Table 4. 9: Logistic Regression of Factors Determining Rice Commercialization

Variable	Commercialization	
	Coefficient	*Standard Error*
Own Radio	0.440	(0.348)
Credit Access	-0.334	(0.440)
Remittances and Non-farm income	**-0.672****	**(0.336)**
Age	0.0338*	(0.0175)
Rice Experience	-0.006	(0.014)
Motorable Road	**2.165*****	**(0.407)**
Extension Contact	**2.734****	**(1.082)**
constant	-0.520	(0.626)

*****P<0.01, **P<0.05, *P<0.1.**

Standard errors in parenthesis

Source: Survey Data (2022)

As revealed from Table 4.9, the coefficients corresponding to different factors provide insight into the direction and magnitude of their influence on the probability of households participating in the rice commercialization process. The propensity scores that will be estimated in this first step will be used to match the treatment and control groups in later stages of the results. The logistic regression results in the context of rice commercialization highlight variables that affect household income in Northern Ghana. Each predictor variable's coefficient provides information about how likely it is to engage in rice commercialization. Notably, factors including radio ownership, loan availability, remittances and non-farm income, age, rice-growing experience, the existence of a motorable road, and extension contact are all taken into account.

The results of the logistic regression analysis showed that Remittances and Non-farm income, Age, Motorable Road, and Extension Contact were the variables that

significantly predict rice commercialization. It is also revealed from the negative coefficient of Remittances and Non-farm income that rice commercialization was less common in the households that receive remittances or engaging in non-farm activities. The positive coefficients of Age, Motorable Road, and Extension Contact for rice commercialization in the household are offer very valuable insights into the multi-dynamics of the influences of agricultural practices in Northern Ghana. Starting with the first variable, the positive coefficient of Age indicates that older households are more likely to undertake the commercialization of rice production. This may reflect the effects of experience and accumulated knowledge in older households, making commercial farming complexities more manageable. Another important trend that can be observed is the positive coefficient associated with access to motorable roads, underpinning thereby the importance of transport infrastructure in enabling gains from rice commercialization. Motorized road access guarantees rice produced by smallholder farmers, access and effective transportation to the market, hence reducing logistic challenges and increasing economic viability in commercialization of farming activities. Finally, the positive coefficient for extension contact reflects the pivotal role that agricultural extension services play in rice commercialization. Households with active extension contacts will have access to information, adoption of modern techniques, and market conditions, hence creating an enabling environment for rice commercialization. These results are consistent with previous research (Omiti et al., 2009b) that shows how infrastructure, demographics and external assistance drive farmers' decisions to commercialize. The coefficients for Motorable Road and Extension contact show the role of infrastructure and extension services in determining rice commercialization which is remarkable. The benefits of having a motorable road

imply that better transport infrastructure eases rice farmers' access to markets, thereby able to participate more actively in agricultural commercialization activities. Furthermore, the positive coefficient of extension contact shows how important agricultural extension services are in giving farmers access to resources and important information that motivates them to engage in agricultural commercialization activities. These results are consistent with similar studies (Bonye et al., 2012; Maulu et al., 2021) that highlights the relevance of agricultural extension services and rural infrastructure in agricultural development.

Complex interactions within households are manifested in the varied impact of age, remittances and non-farm income on rice commercialization. Older households, who would be more equipped with experience in resource management, may have a more positive influence on mtheir commercialization drive due to the positive link found between age of household head and rice commercialization. The negative correlation between remittances or non-farm income and commercialization suggests that households that receive or generate non-farm income or remittances might act as a barrier to prioritising rice commercialization as a major income source.

4.5.3 Impact of Commercialization on Household Income

This section shows the results of the Propensity Score Nearest Neighbour Matching and Propensity Score Matching to provide relevant information on how rice commercialization affects household income in Northern Ghana.

Table 4. 10: Treatment Effects of Commercialization on Household Income

Model		Observed Coefficient	Standard Error	P>|z|
Propensity Score Matching	ATT	0.407	0.041	0.000
	ATE	0.361	0.041	0.000
Propensity Score Nearest Neighbor Matching	ATT	0.415	0.057	0.000
	ATE	0.367	0.053	0.000

Source: Survey Data (2022)

The two important measures for the causal relationships between rice commercialization and income are the Average Treatment Effect (ATE) and the Average Treatment Effect on the Treated (ATT) coefficients. It is important to verify in a propensity score matching analysis if the calculated propensity scores balance the characteristics of participants and non-participants. This equilibrium guarantees that the groups under comparison have comparable baseline characteristics. Given their estimated propensity scores, the results aim to determine whether farmers who commercialize are similar to those who do not commercialize. This stage provides the degree of overlap in the propensity ratings between participants and non-participants. It helps identify the shared area of support. Propensity score matching cannot account fully for selection bias and unobserved farmer characteristics that may affect household income and choice to commercialize. The reliability of our estimations may be impacted by hidden biases in cases when certain farmer attributes are not captured. The accuracy of estimating how commercialization affect household income may be impacted by this hidden bias. We apply the kernel density balancing plot and the Covariate balancing summary statistics. This approach ensures the validity of the conclusions on the influence of commercialization on household income by enabling a better understand how resilient our findings are to any hidden biases.

The Average Treatment Effect (ATE) coefficient of 0.361 obtained by propensity score matching reveals that, on average, participation in rice commercialization results in an increased household income of 36.1%. This significant positive effect suggests that rice commercialization is key to enhancing the economic well-being of households in Northern Ghana. The ATE is a valuable metric for policymakers and researchers because it provides a generalized view of the overall effect of rice commercialization on the levels of income. In general, the results corroborate with literature showing a positive correlation between agricultural commercialization and household income (Abu & Haruna, 2017). In addition to the ATE, the ATT refines this analysis because the ATE only examines the group that received treatment which is the households that were participated in the commercialization of rice. With the estimates, the observed ATT coefficient of 0.415 means, for a given average household that sells rice commercially, the average increase in income is 41.5%. This detailed view gives focused impacts among households who participate in rice commercialization therefore giving specific insight into the benefit accrued to this subgroup. The statistical significance ($p = 0.000$) underscores the finding as very robust and reliable. Extensive gains in income through both ATE and ATT underline the potential role rice commercialization can play in fostering economic development in the Northern part of Ghana. This implies that policies aimed at increasing the level of commercialization of rice in a sustainable manner will have the added advantage of improving rural livelihoods in general.

The calculated ATT of 40.7% seeks to examine the specific impact of rice commercialization on households involved in active commercial activities. This marginally higher effect for the treated implies that, it is important not to consider only the average effect of treatment but at effects differentiated by those who

participate directly in commercial activities. These findings align with theoretical frameworks proposed by Barrett et al. (2012b) suggesting that agricultural commercialization acts as an avenue to raise household income. The idea is that the ATT would capture the effect localized on treated households highlighting the relevant effects of commercialization strategies. The p-values of 0.000 are statistically significant for the ATT and ATE coefficients thereby strongly supporting the robustness of the treatment effects. Therefore, the extremely low probability of these effects occurring by chance reinforces that these results shown are reliable and valid. This level of statistical significance reinforces confidence in concluding that rice commercialization has impacts on household income in Northern Ghana. The significance of the aligns with the emphasis put on statistical robustness in the estimation of treatment effects (Wager & Athey, 2018). The results have substantially treatment effects which have significant implications for agricultural development in Northern Ghana. The positive impacts of commercialization on household income show the potential benefits of supporting and encouraging commercialization as an avenue to enhance economic well-being of farm households in Northern Ghana. These results align other studies on how commercialization can address the dual goals of better economic growth and poverty reduction in rural areas (Yaro et al., 2017 ; Johann et al., 2013). The results are more confident because the p-values are below traditional significance thresholds. This statistical robustness strengthens the validity of the conclusion that rice commercialization has a significant effect on household income in Northern Ghana increasing the dependability of the findings.

The results from the propensity score nearest neighbour matching provide firm support for the positive impact of rice commercialization on household income in

Northern Ghana. The average treatment effect on the treated and average treatment effect coefficients, which measure the average change in income due to engaging in rice commercialization are positive at 0.415 and 0.367, respectively. These values suggest that the average household income among those involved in rice commercialization has increased significantly compared to non-commercializing households.

A comparison of the estimation results between PSM and NNM yields consistent evidence of positive effects of rice commercialization on family income. In the case of PSM, although the estimated value of ATET is relatively lower, which is 0.4072, compared to that obtained through NNM (0.4154), they both mean the annual household income significantly increased among farmers selling rice compared to their counterparts who have not sold it. The p-values of both the models are 0.000, indicating from 1% statistical significance level, the effect is not a matter of chance. Both methods gave similar values, but the standard error from PSM estimates is 0.0413, while the one from the NNM was 0.0578, hence, it is more accurate. The slightly higher standard error in NNM suggests that the variation in matched pairs is greater using the Mahalanobis distance metric than with propensity scores.

The propensity score matching technique ensures comparison through the creation of comparable treatment and control groups which enhances the credibility of the treatment effects. The observed positive treatment effects have impacts for the development process in Northern Ghana. Rice commercialization can be viewed therefore as a means of raising household income. Promoting and supporting commercial activities within the rice sector could be one way through which economic growth together with poverty reduction can be fostered in the Northern

sector of Ghana. There are several other benefits of commercializing rice other than the economic benefits. Commercialization of rice may lead to higher living standards, ease of access to health and education facilities and high resilience to economic shocks through the rise in household income. Furthermore, commercialization has the tendency to reduce poverty in line with the SDGs, especially SDG 2 sustainable agriculture, achievement of food and nutrition security and the reduction of hunger and SDG 1 which seeks to end poverty. The findings thus show in the context of Northern Ghana that agricultural development, income improvement, and poverty reduction are interdependent (Baffoe et al., 2021).

The Rosenbaum bounds test for sensitivity of ATT was employed examine unobserved bias (See appendix B). At $\Gamma = 1.0$, representing no unobserved bias, the estimated ATT is 59.90 with a 95% confidence interval ranging from 54.37 to 65.58, suggesting a strong and very precise treatment effect. In fact, at $\Gamma = 1.5$-which corresponds to moderate unobserved bias-the ATT is now (50.04, 70.30) with a wider confidence interval of (44.61, 76.35), suggesting more uncertainty yet still a strong effect. Notice that the significance levels (sig+ and sig-) remain 0, implying that the estimated treatment effect is statistically significant in the presence of moderate unobserved bias. This stability implies that even when unobserved variables double the treatment assignment probability, the estimated ATT remains reliable. However, further increases in Γ could test its stability. In general, the results show that the treatment effect is valid and not too sensitive to unobserved confounders based on realistic assumptions.

The covariance balancing for validity was also employed (See Appendix C). The balance results for the covariates depicted that the matching improved comparability between the treated and control groups. Most of the standardized differences have

been reduced to an acceptable level, indicating a minimization of bias. Residual imbalance still remains, especially in years of rice farming and Motorable roads, which may be sensitive to unobserved confounders. The variance ratios are closer to 1, indicating that the distribution of covariates has also improved. The matching procedure was thus effective in reducing selection bias.

4.6 The role of agricultural support services on crop commercialization in northern Ghana.

This section presents agricultural support services in terms of commercialization of rice in Northern Ghana. Agricultural support services such as access to credit, extension, access to inputs, and access to market drive traditional subsistence farming towards commercial farms. Agricultural support services extend important information to farmers about new technology and farm techniques, and thus enhance productivity and profitability.

4.6.1 Agricultural Support Services

From figure 4.2, 83.81% of rice farm households got credit support, showing a high reliance on outside funding for agricultural operations

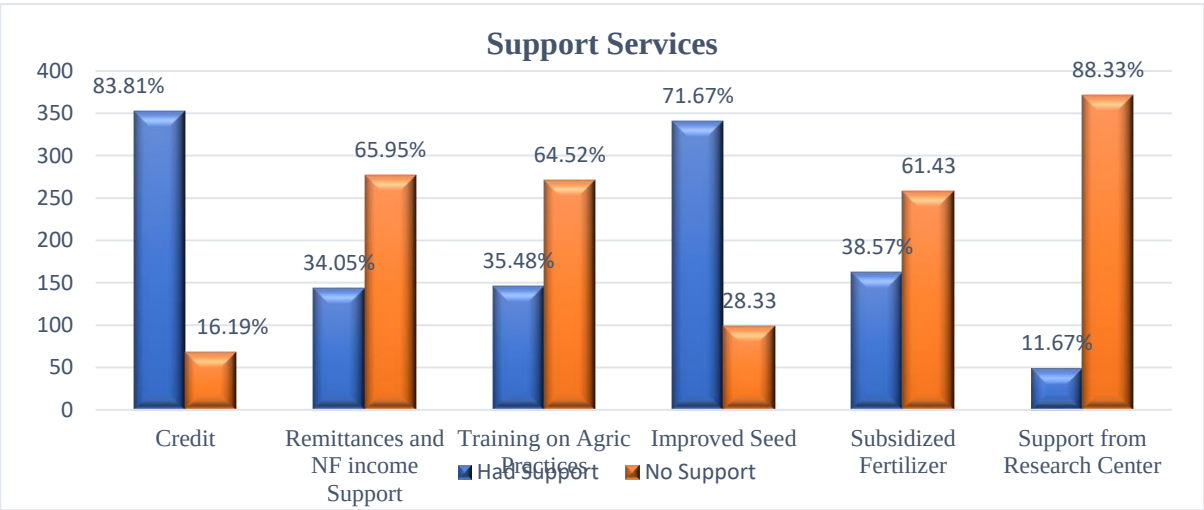

Figure 4. 2: Agricultural Support Services
Source: Survey Data (2022)

. This result is consistent with literature (Abdul-Rahaman & Abdulai, 2020;Abu & Haruna, 2017) that highlights the critical role that credit plays in raising agricultural output and encouraging commercialization. There is a requirement of financial support to be provided to farmers so that they can invest in machinery, technology and inputs to increase crop yields enhance better farming practices that over time, will lead to agricultural commercialization. Among the rice-producing households, 65.95 percent had remittances or non-farm income diversification as studies (Nkegbe et al., 2024; Djurfeldt et al., 2018) emphasize how non-farm income tends to reduce poverty and increase agricultural commercialization. The results suggests that the agricultural income of the rural rice producing households was not the only source of livelihood, non-agricultural income and remittances could act as a financial safety net that enhances the commercializing of their agricultural produce. 35.48% of the households have had access to agricultural training services which serve the purpose of developing knowledge and skills about modern agricultural technology. This is consistent with research that shows how training may help farmers become more productive, increase their capabilities, and promote agricultural commercialization (Chapoto et al., 2013). Farmers that receive agricultural training are better able to engage in commercial marketplaces, adopt new practices, and make educated judgments.

A majority of the households (71.67%) reported having access to improved seeds. This underscores how important seed technology is in raising agricultural yields and quality. Better seeds are one of the major drivers of higher productivity and higher productivity is one of the main determinants of agriculture's commercialization. The results point out that commercialization of rice in Northern Ghana may be influenced by interventions that provide access to high-quality seeds. It is also worth noting that

38.57% of the respondents indicated they had access to subsidized fertilizer. In this regard, even though fertilizer subsidies are one of the common forms of support for agriculture, not every rice-producing household in Northern Ghana have access to these subsidized fertilizers for production. This raises important questions about how inclusive and efficient fertilizer subsidy policies and these have been argued in literature (Djurfeldt et al., 2018).

4.6.2 Role of Support Services on Agricultural Commercialization

Agricultural support services play an important role in enhancing the productivity, market access and farmer profitability in rice commercialization in Northern Ghana. Table 4.11 and 4.12 respectively presents the role of agricultural financial support services and non-financial support services in rice commercialization in Northern Ghana.

Table 4. 11: Financial Support Services and Agricultural Commercialization

Variable	Sold Rice (%)	Did Not Sell (%)	Pearson's Chi- Square	P-Value
Credit Support				
Had Credit Support	69.76%	14.05%	0.1754	0.675
No Credit Support	13.81%	2.38%		
Remittances and Non-Farm Income				
Received Non-Farm Income	26.43%	7.62%	5.589	0.018
Did Not Receive Non-Farm Income	57.14%	8.81%		

Source: Survey Data (2022)

The results emphasize how important non-farm revenue and remittances are in determining how rice has been commercialized in Northern Ghana. Compared with households that did not commercialize rice, 57.14%, households that sold rice did not receive remittances and non-farm income whiles 26.43% that sold rice receive remittances and non-farm income. These results present the difference between

those who did and those who did receive remittances and non-farm income. This discrepancy underscores the significance of having multiple revenue streams on farmers' choices on rice commercialization. Further results from the Pearson's Chi-square test (Chi-square = 5.589, p-value = 0.018) show how statistically significant the results are. These findings suggest that while non-farm income and remittances could imply financial stability, they may influence farmers to prioritize subsistence farming over market-oriented activities.

In Ghana's rural communities, Awunyo-Vitor et al. (2014) have identified the importance of multiple income streams and the role of non-farm income in supporting livelihoods at the household level. The complexity of livelihood options within Ghanaian agriculture sector provides useful insights through which to evaluate the observed lower percentage of rice sold by farmers who get non-farm income. This result is in line with the complexity of rural livelihoods where farmers engage in multiple income generating activities to generate income for the improvement of economic adaptability. A major strategy employed by farmers and known as income diversification which include engaging in non-farm activities, which helps them reduce risks related to dependence on solely farm-generated revenues. The findings of this study support the Awunyo-Vitor et al. (2014) who concluded that, the analysis of various strategies employed by farmers in handling the uncertainties of their livelihoods in agriculture is crucial to agricultural productivity. However, agriculture is the key driver of the economy of Ghana and the influence of non-farm income and remittances on rice commercialization is worth noting. These results underscore that farmers with multiple sources of income have lower rice sales percentage. In as much as rice production provides key support to farmers' livelihoods, increasing dependence on non-farm income shows flexibility

and resilience in approaches to livelihood. The dynamics of diversification of sources of income is relevant to an economy such as Ghana's, where agriculture remains a very important driver of economic growth. The results are in alignment with the work of Anang & Apedo (2023) which examined the importance of income diversification for Ghanaian rural development. According to Agyeman et al. (2014), diversification including revenue from sources other than farms helps to reduce poverty and promote sustainable rural development. In line with Agyeman et al. (2014) the less proportion of rice sold by farmers with non-farm income implies that non-farm pursuits may operate as a safeguard against an excessive reliance on rice commercialization. On the contrary, the higher percentage of rice sold by farmers who do not earn a living from their farms suggests that there may be a connection between the lack of such revenue and a stronger reliance on rice commercialization. This result is in line with the research conducted by Mathenge et al. (2015) and Senadza (2012), that focused on the challenges associated with restricted alternatives for income diversification in the rural communities. The results indicate that the non-farm income for the households is less diversified, making them more concentrated on and dependent upon commercialization of rice for financial security.

Table 4. 12: Non- Financial Support Services and Agricultural Commercialization

Variable	Sold Rice (%)	Did Not Sell (%)	Pearson's Chi-Square	P-Value
Agricultural Training Services				
Had Training Support	34.76%	0.71%	34.95	0.000
No Training Support	48.81%	15.71%		
Access to Subsidized Fertilizer				
Had Access to Subsidy	32.62%	5.95%	0.19	0.662
No Access to Subsidy	57.14%	10.48%		
Access to Improved Seeds				
Had Access to Improved Seeds	63.33%	8.33%	17.83	0.000
No Access to Improved Seeds	20.24%	8.10%		
Support from Research Center				
Had Support from Research Center	10.71%	0.95%	2.76	0.097
Did Not Get Support from Research Center	72.86%	15.48%		

Source: Survey Data (2022)

From the results of the study, on the access to agricultural training services, the results showed that there is a significant relationship between agricultural training services and commercialization of rice. The results revealed that, 34.76% of the households with training support sold rice while 0.71% of farmers who did not have training support sold rice. On the other hand, 48.81% of the households without training support sold rice compared to 15.71% of farmers with training support who did not sell rice. The results of Pearson's Chi-square test indicated a significant relationship: (Chi-square = 34.950, p-value = 0.000). This suggests that agricultural training services are very important in influencing the decisions of rice farmers to

commercialize their production. This corroborates with research on agricultural extension services in Ghana, which emphasizes that farmers who received training had improved farming practices, output, and participation in markets (Danso-Abbeam et al., 2018; Anang & Asante, 2020) The higher percentage of rice farming households that sold rice in the category of farmers who received training support is also consistent with studies that show how agricultural trainings transforms Ghanaian smallholder farmers. Therefore, the training programs provide information and train farmers in skills that will enable them to adopt new technologies that improve yields and make better market decisions. The statistically significant relationship that has been observed between the percentage of households that sold rice and access to agricultural training services underscores transformational tendencies of agricultural training initiatives in boosting commercialization of rice production in Northern Ghana. The higher proportion of households that sold rice among farmers that receives training services also indicates the beneficial effects of knowledge and skills development on their capacity to participate in commercial agriculture more successfully. The significance of the observed relationship underscores two key aspects which include the importance of specific factors and also, concerns about the effectiveness of existing extension services and utilization of available training opportunities in the region. This concern is evident in the proportion of households that sold rice but had no access to agricultural training services which may point out a relationship between training and increased productivity or market participation. The disparity points to weakness in information and expertise required for effective rice production and marketing. Related literature (Abdul-Rahaman & Abdulai, 2020; Anang & Asante, 2020) emphasizes that effective extension services and farmer group membership are very

critical in promoting knowledge, technology transfer and marketing output. Effective trainings can therefore make farmers potent by equipping them with tools necessary in meeting the challenges in the rice market. This therefore implies that enhancing the knowledge, accessibility and applicability of the trainings and elimination of the other barriers to participation in the trainings would enhance the rice commercialization by this group. Several studies have highlighted challenges in agricultural extension provision and its effectiveness hence, there is a need for targeted situation-specific interventions to influence its effect (Somanje et al., 2021)

The results of the study further show how access to improved seeds has effects on the commercialization of rice in Northern Ghana. While the proportion of households that sold rice and had access to improved seeds stood at 63.33%, the proportion of households that sold rice and did not have access to improved seeds was 20.24%. A significant relationship was observed by the Pearson's Chi-square test (Chi-square = 17.83, p-value = 0.000) highlighting the significant effects of improved access to seed has in influencing farmers' decisions to commercialize rice. This result is consistent with literature (Quarshie et al., 2021;Chapoto et al., 2013) that focuses on raising agricultural production and encourages commercialization by ensuring better quality inputs especially in the form of seeds. The high percentage of households that had access to agricultural training services and sold rice signifies the role agricultural innovation and technical developments play in agricultural growth. This aligns with the findings of Buah et al. (2011) that places strategic emphasis the integration of advanced technology to improve productivity and income levels among smallholder farmers. The commitment to leveraging technological advancement underscores a progressive approach toward tackling the challenges facing agricultural commercialization. In doing so, advanced technology

could therefore alter the farming practices of its farmers toward embracing precision agriculture, mechanization and digital innovations. The emphasis on technology adoption signifies that it could transform farming practices toward optimization, efficiency improvement and eventually socioeconomic upliftment for smallholder farmers. Furthermore, the link between this research findings and agricultural development strategy provides a well-informed approach to demonstrating the importance of evidence-based decision-making in fostering sustainable agricultural growth and rural development (Buah et al., 2011). Thus, it is acknowledged that Ghana's plans for sustainable agricultural growth include access to better seeds. The findings underscore the relevance of increased seed availability among smallholder farmers in Northern Ghana as this is highlighted by the statistically significant relationship found between commercialization of rice and access to better seeds.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, conclusions and recommendations revealed from the analyses and discussions of results in various chapters of the study. The chapter is made up of the summary of the study (section 5.2), major findings of the study (section 5.3), conclusions (5.4), policy recommendations (section 5.5) and suggestions for future studies (section 5.6).

5.2 Summary of the Study

In view of the fact that the Northern part of Ghana is the most significant centre for rice production, its commercialization is lower compared to that of imported rice. This is because smallholder farmers remain at subsistence levels of operation despite their potential for production at commercial levels. Appreciating the need to commercialize agricultural production, the Ghanaian government in collaboration with international development partners has concentrated its efforts on the business side of crop production. Coupled with this is the government's Planting for Food and Jobs program aimed at increasing crop production and its commercialization. In the rice sector, various non-governmental organizations have actively supported initiatives to promote rice production and commercialization in Northern Ghana. Despite the government and non-governmental interventions in the commercialization of rice in the country, there is still a gap between the domestic demand and the domestic supply of locally produced rice. With a gap in research on the impact of commercialization on the welfare of rice-producing households, the thesis aims to investigate Rice Commercialization and Rural Household Welfare in Northern Ghana

A survey of a cross-section of farmers was used to acquire the quantitative data needed for the study. A multistage sampling technique was employed to select 21 farm households per community in 20 communities from 4 districts of Northern Ghana and in all 420 rice producing households were selected for the study. Descriptive statistics was used to describe the various variables under study. It was also used to explore the role of agricultural support services on crop commercialization in Northern Ghana. The Binary probit model was employed to examine the determinants of agricultural commercialization. The endogenous switching regression model was used in assessing the impact of commercialization on per capita consumption expenditure and the Propensity score matching techniques was used to assess the effects of commercialization on household income.

5.3 Major Findings

5.3.1 Objective One

From the study, smallholder rice farmers in Northern Ghana strategically allocate rice production to sales of 66%, an indication of their active participation in the local or regional markets. This confirms the importance of market-oriented agriculture for these farmers in making significant contributions to local economies and contributing to household financial stability. The results further showed that 15% of the rice production was allocated for consumption, with this proportion of rice allocated solely for the consumption needs of the farm households. Furthermore, 2% of the rice produced is allocated for gifts and in this case, the social or cultural customs are followed and community bonds are built. From the findings, 17% of the rice produced by the farmers is stored which shows the farmer is aware of how to mitigate risks in order to have stable food amid market uncertainties or price fluctuations. Further results of the study show that in Northern Ghana, subsistence-

oriented market participation existed as 17.14% of households produce a significant but not dominant amount of rice mainly for subsistence while a small percentage (1.90%) of the production are surplus-oriented market participants characterized by producing more than what is required for consumption with excess sold out. The majority of the rice production (80.95%) are commercial oriented and place greater emphasis on strong integration into the market system suggesting commitment to rice production for household needs and profit by actively engaging with local and regional markets.

Further findings from the study underscored significant determinants were found to influence rice commercialization among the smallholder farmers: the age of household head was identified as a significant determinant with a positive relationship in that the older the household head, the higher the probability of being engaged in rice commercialization. In addition, household size was found to be a significant determinant of rice commercialization. Thus, the larger the household sizes, the higher the likelihood that the households will take part in commercialization. The results also indicated that rice farming experience was statistically significant with a negative sign, meaning that those farmers who have worked in rice farming for a longer period are less likely to adopt commercial ways. The availability of labour had an influence on commercialization in that the larger households have a higher likelihood to result in rice commercialization.

Additionally, other variables found to have significant effects on rice commercialization were non-agricultural factors, specifically ownership of a television, extension contacts, and distance from home to market centres. Ownership of a television set was a very strong determinant of commercialization and has the

tendency to influence farmers through the media. Extension Contact show a positive relationship with commercialization hence offering the required access to resources, information and expertise available through extension services. Distance from home to market centre and the accessibility of motorable roads connecting homes to market centres also emerged as significant factors that enhance the engagement in rice commercialization. The likelihood of rice commercialization is significantly determined by shorter distance and better conditioned road infrastructure to and from homes to market. These findings help to underline the multi-dimensionality of considerations involving smallholder rice farmers in Northern Ghana with regard to taking up the commercialization of rice production, which is drawn both from agriculture and socioeconomic sectors.

5.3.2 Objective Two

The results showed that in northern Ghana, rice-producing households have varied patterns of expenditure where the average expenditure is GHS 241.59 on food and GHS 1595.20 on non-food items. Standard deviations for both categories are very high hence showing there are extreme variations across the households in terms of consumption expenditure showing specific inclinations in spending. The variations in average expenditures for food and non-food items set out different priorities in terms of household resource allocation where some households would prioritize sufficient food supplies but give a higher budget to non-food items, probably driven by aspirations for better living conditions, health and education, as studies related to changing consumption patterns have suggested.

The findings further establish that on average, the per capita consumption expenditures for the households involved in rice commercialization in Northern

Ghana is GHS162.798, compared to non-participants with an average of GHS 101.151. Using the endogenous switching regression, the results show an average treatment effect of 61.647 with a t-value of 22.489 highly significant at the 1% level, thereby underscoring the significantly large effect of rice commercialization on the per capita household consumption expenditure of participant households in commercialization. It is therefore presented that the welfare of households involved in rice commercialization is very high resulting in improved living conditions. The statistical significance of the Average Treatment Effect on the Treated (ATT) estimate suggests rice commercialization has a positive effect on household welfare in Northern Ghana and therefore, makes participation in commercial agricultural activities economically viable.

5.3.3 Objective Three

The results show that the income distribution of rice producing households in Northern Ghana indicates a majority (65.24%) of the households in the GHS 1001–5000 income range. This implies that there is high concentration toward the middle-income range. It shows that rice commercialization could have positive impacts on household earnings as market-oriented agriculture allows farmers to generate additional income by selling the extra produce they harvest. The distribution however highlights the economic heterogeneity among rice-producing households with differences in income categories reflecting different levels of their economic well-being. Structural constraints in the commercialization process include limited access to markets, resource endowment variations and socioeconomic inequalities. Targeted interventions, input support and tackling socio-economic gaps could help reduce the income inequality prevailing among rice-growing households of Northern Ghana.

The propensity score matching analysis showed a strong positive effect of rice commercialization on household income in Northern Ghana. The Average Treatment Effect (ATE) coefficient of 0.361 implies that on average, there is a 36.1% increase in income associated with rice commercialization. This conforms to existing literature pointing out the positive correlation between agricultural commercialization and household income. Further assessment through the Average Treatment Effect on the Treated (ATT), it emphasizes on a more substantive 41.5 percent growth in the income levels of households actively engaged in rice commercialization. The statistical significance of these coefficients reinforces the robustness of these findings suggesting that policies aimed at promoting sustainable rice commercialization could play an important role in reducing poverty and fostering overall rural development in Northern Ghana. The ATE and ATT coefficients show very significant p-values hence showing the reliability and validity of the results from a statistical point of view. These findings are therefore of importance toward the formulation of agricultural development strategies in Northern Ghana with major emphasis placed on rice commercialization as a potential avenue for improving household income. It feeds into the broader debate on the role of commercialization in causing reduced poverty and inclusive growth in rural areas and specifically, how it requires targeting interventions and support to enhance the economic well-being of households engaged in rice production.

5.3.4 Objective 4

The findings show an influence of non-farm income and remittances on rice commercialization in northern Ghana. Farmers engaged in non-farm activities or received remittances would have a lower percentage of rice sold compared to those not engaged in non-farm activities or those who have not received remittances. This

indicates the role of diversified income streams among farmers and suggests that non-farm enterprises could act as protection from over-reliance on rice commercialization.

The results align with existing studies on the complexities of rural livelihoods and the need to consider a portfolio of income-earning activities in order to address the insecurities of agriculture. Furthermore, the findings reveals that agricultural training services plays an important role in rice commercialization. Majority of farmers who had access to agricultural training services trainings sold rice. In effect, knowledge and skill development transform farmers' capacity to participate more successfully in commercial agriculture. This further underpins the importance of relevant interventions including effective extension services towards productivity enhancement and market participation.

The study also revealed that improved seeds are essential for rice commercialization. Access to improved seeds significantly influence the commercialization of rice. Majority of farm households who had access to improved seeds sold rice whiles those who did not have access to improved seeds did not sell rice. This underlines the role of innovation and technological change in agriculture in boosting production and encouraging commercialization. The results are consistent with the global drive toward precision agriculture, mechanization, digital innovations and other technological changes that can transform the adoption of agricultural practices for the socioeconomic upliftment of smallholder farmers. In general, this finding underlines the complexity of factors that underpin rice commercialization in Northern Ghana and brings some salient lessons to the forefront for policymakers

and practitioners concerned with sustainable agricultural growth and rural development.

5.4 Conclusion

The in-depth analysis of small-holder farmers commercialization of rice in Northern Ghana provides diverse insights into the complex dynamics influencing agriculture and welfare in the region. Notably, the results reveal the significance of non-farm income and remittances on rice commercialization. These findings place emphasis on the fact that income diversification strategies could play significant role in reducing farming households' exposure to risk and enhancing financial resiliency. The study also shows how access to improved seed and access to agricultural training services influence rice commercialization underscoring the role of knowledge sharing and technological innovation in raising farmer productivity and commercialization. From a theoretical perspective, these findings add depth to the knowledge of the complex dynamics that shape agricultural commercialization in rural areas and provide critical directions to industry actors who seek to drive sustainable agricultural development in Northern Ghana.

The study further revealed several factors that determine rice commercialization in Northern Ghana which include location, institutional, socioeconomic, and technological factors. Factors under location specific factors such as distance to market centres, the accessibility of motorable roads, and distance from home to the marketplace are major determinants influencing farmers' decisions to participate in rice commercialization. The institutional factors include membership of farmer-based organizations, access to extension services, and technological factors with respect to farmers' experience in rice cultivation as key drivers that influence the

participation in rice commercialization. Furthermore, socioeconomic variables, which encompass age, household size, labour availability, owning a television, and contact with extension services all shape the decision by households to participate in rice commercialization.

Rice commercialization has had a significant effect on the household consumption expenditure and welfare. With more income generated from rice commercialization, due to the engagement of farmers in the market-oriented agricultural practices, the study revealed significantly higher per capita consumption expenditure. On the same note, the study establishes a significant relationship between commercialization and household income, underscoring the derivation of gains from participation in rice commercialization. This highlights the potential of market-oriented agriculture in individual consumption improvement and broader economic well-being. The study identifies a low trend of access to agricultural training services among households. The low access to agricultural training services by farmers was shown from the findings despite the important role support services play in rice commercialization. In effect, farmers in Northern Ghana are constrained in accessing these training facilities with which they acknowledge playing a very important role in their production and commercialization effort.

5.5 Policy Recommendations

- **Supporting Access to Improved inputs and Extension Services:** Government policies especially those aligning with the Planting for Food and Jobs (PFJ) and other governmental and non-Governmental tailored policies must emphasize and build on services that ensures that smallholder rice farmers in Northern Ghana receive timely access to subsidized improved seeds,

fertilizers, Extension support and mechanization services. This includes the provision of consistent and high-quality inputs at an affordable price for smallholder farmers, along with some complementary interventions meant to enhance farmers' knowledge and skills through intensified interaction with extension services.

- **Investment in Rural Infrastructure:** Government policies should emphasize on the investment in rural infrastructure such as building a road network that connects farming communities to the markets in Northern Ghana. Transportation facilities are important to reduce market access problems among smallholder farmers. The movement of goods from the rural to major market centers should be made easy in order to help farmers transport their produce in a fast pace therefore reducing post-harvest losses, hence stimulating increased participation in more commercial activities. Such policy means not only benefit to farmers but also a drive to commercial activities in the rural area which eventually leads to rural development.
- **Market Creation and Income Enhancement:** The Ministry of Food and Agriculture in Ghana should in collaboration with Ghana Rice Interprofessional Body (GRIB) and private agribusiness firm should establish structured market channels such as warehouse receipt systems, contract farming agreements and government-backed procurement programs to ensure guaranteed demand for locally produced rice. Essentially, strong market linkages in Ghana should be built both locally and regionally to create continuous demand for locally produced rice. Similarly, policies should target value addition initiatives aimed at raising the quality and competitiveness of locally grown rice. This will give farmers a better chance of getting optimal prices for their produce leading to the

increase in their income. In effect, this will reduce poverty and improve their standard of living in the rural areas.

5.6 Suggestions for Future Research

The study suggests that future research into the rice commercialization and rural household welfare in Northern Ghana needs to be undertaken through longitudinal studies. This could involve the monitoring of participating households over several years to examine the dynamics of the changes in their incomes including possible fluctuations or any long-term trends and challenges likely to face farmers producing rice commercially.

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APPENDCES

Appendix 1: SURVEY QUESTIONNAIRE

A Survey to Assess Rice Commercialization and Rural Household Welfare in Northern Ghana.

This Questionnaire forms part of my M.Phil. Research at the University for Development Studies Nyankpala Campus, I am undertaking a survey to assess the Rice Commercialization and Rural Household Welfare in Northern Ghana. I would be grateful for your participation in the completion of this questionnaire. The interview is completely voluntary and all survey information will be kept confidential. We will not tell others and your personal information will not be disclosed. You may withdraw from the study at any time. Please may I proceed interviewing you?

Do you agree to participate in the interview? 1. Yes [ ] 2. No [ ]

Date of interview Date [ ][ ] Month [ ][ ] Year [2][0][ ][ ] Interviewed by _____

A. HOUSEHOLD IDENTIFICATION AND BASIC HH INFORMATION

A1	District	☐ 1 Sagnerigu ☐ 2 Savelugu ☐ 3 Tolon ☐ 4 Kumbungu	**A1a**	Community	
A2	Respondent name		**A2a**	Respondent Sex	☐ 1 Male ☐ 2 Female
A3	Respondents Age	|_____| Years			
A4	Marital Status	☐ 0 Single ☐ 1 Monogamously married ☐ 2 Polygamously married ☐ 3 Widowed ☐ 4 Separated ☐ 5 Divorced			
A5	Respondent's educational status	☐ 0 illiterate ☐ 1 Read and Write ☐ 2 (1-12) Primary to Secondary level ☐ 3 (13) Technical and Vocational education ☐ 4 (14) University ☐ 5 (15) Postgraduate			_____
A6	Relationship with the HHH	☐ 1 Household Head ☐ 2 Spouse ☐ 3 INLAW ☐ 4 Others……			
A7	Main Occupation HHH	☐ 0 Unemployed ☐ 1 Farming ☐ 2 Self Employed ☐ 3 Salaried Employment			

		☐ 4 Others……			
A8	HH Size *Resident at least 3 months during past 12*		**Male**	**Female**	**Total**
		A8a Less than 5 years (0-59 Months) of age			
		A8b 5-14 years of age			
		A8c 15-64 years of age			
		A8d 65 years of age & greater			
		A8e Total size (verify with the interviewee)			
A9	How many years of experience do you have in cultivating rice?	|_____| Years		
A10	What is the Average Annual HH income?	☐ 0 Below GH 1000 ☐ 1 GH 1000 – GH 2000 ☐ 2 GH 2001 – GH 3000 ☐ 3 GH 3001 – GH 5000 ☐ 4 Above 5000			
A11	Do you belong to an FBO	☐ 1 – YES ☐ 0 – NO			
A11a	If yes, does the FBO undertake Collective rice Sales	☐ 1 – YES ☐ 0 – NO			

B. Rice Production

B1	Has your household cultivated Rice in the 2020 planting season?	☐ 1 – YES ☐ 0 – NO	If yes skip to B3
B1a	If "no" when is the last time your HH cultivated rice?	☐ 1 _____	Skip to B3
B2	Which varieties did the HH grow in the last 12 months? **(check all that apply)**	☐ 1 - AGRA ☐ 2 - JASMINE ☐ 3 - MANDII ☐ 4 - ABERIKUKOGU ☐ 5 – TOGO MARSHALL ☐ 6 - TOX ☐ 7 - ANYOFULA ☐ 8- MR IDDI	☐ 9 – OTHER (SPECIFY)_____

B2a	Is this Variety(s) Improved?	☐ 1 – YES ☐ 0 – NO ☐ 88 Do not know
B2b	Who decided to plant the selected variety/ies?	☐ 1 -MAN ☐ 2 -WOMAN ☐ 3 -BOTH ☐
B2c	What was the source of seed in the last 12 months? **(check all that apply)**	☐ 1 – RECYCLE OWN SEEDS ☐ 2 – PURCHASED FROM MARKET ☐ 3 - FREE FROM NEIGHBORS ☐ 4 - BOUGHT: FROM ORGANIZATIONS ☐ 6 - FREE: FROM AN NGO ☐ 7 - BOUGHT: INDIVIDUAL FARMER ☐ 8 – OTHER_____
B2d	What was the quantity of seeds that you planted?	☐ _____ kg ☐ 88 - Do not know
B2e	In the last 12 months, how much land was under cultivation for rice?	☐ Area _____ unit ☐ 88 Do not know
UNIT: 1- Sq meter 2-Acre 3-Hectare 4- Are (100 sq m) 5- Timad		
B2f	What was total harvest of this crop in the 2020 season?	☐ quantity _____ unit _____ ☐ 88 Do not know
B2g	Has the yield been Damaged by Rot, drought or eaten by insects/pests/Rodents	☐ 1 – YES ☐ 0 – NO
B2h	What quantity did you consume at home from this harvest?	☐ quantity _____ unit _____ ☐ 88 Do not know
B2i	What quantity did you sell from this harvest?	☐ quantity _____ unit _____ ☐ 88 Do not know
B2j	What quantity did you give to others (gift or somethings) from this harvest?	☐ quantity _____ unit _____ ☐ 88 Do not know
B2k	What quantity did you store from this harvest?	☐ quantity _____ unit _____ ☐ 88 Do not know
B2l	Did you have contract farming over the last 12 months?	☐ 1 – YES ☐ 0 – NO
UNIT: 1=Mini bag (40 kg), 2=Normal bag (96 kg), 3=Bowl (2.4 kg),		

C. Rice Commercialization

Note: Commercialization is when the household sells 1%100% of what is produced

C1	What is the household's major form of cultivating rice?	☐ 1 – SUBSISTENCE ☐ 0 –COMMERCIAL
C2	Has the HH sold Rice in the last 12 months?	☐ 1 – YES ☐ 0 – NO
C2a	If "yes" to how many times did the household Sell rice in the last 12 months?	_____
C2b	If yes, what is the percentage of total produced rice that is sold?	☐ 1 – <25% ☐ 2 – 25%-49.99% ☐ 3 – 50%+
C2c	From the above answer, Do You Commercialize?	☐ 1 – YES ☐ 0 – NO
C3	What Quantity of rice was Sold?	Quantity_____ unit _____ ☐ 88 Do not know ***UNIT:*** ***1***=Mini bag (40 kg), 2=Normal bag (96 kg), 3=Bowl (2.4 kg),
C3a	What Is the Mode of Payment of the rice?	☐ 1 – CASH ON THE SPOT ☐ 2 – CASH AFTER THE BUYER GETS MONEY ☐ 3 – KIND
C3b	How Much was a Unit price of Rice Sold?	amount _____ unit _____
C3c	What is the total sales amount realized?	_____
C3d	What was the HH's income from rice sales in the past 12 months?	|_____| **GHS (***if none, write "0"***)**
C3e	Over the last two years how has income from the sale of rice changed	☐ 1 - GONE UP ☐ 2 - GONE DOWN ☐ 3 - STAYED THE SAME ☐ 4 - DON'T KNOW
C3f	What form was the Rice Sold	☐ 1 – INDIVIDUAL SALES ☐ 0 –COLLECTIVE SALES

C3g	Was there Market Price Information prior to the sales?	☐ 1 – YES ☐ 0 –NO
C4	Where was the rice Sold	☐ 1 AT HOME ☐ 2 AT THE RICE FIELD ☐ 3 RICE MILLING FACILITY ☐ 4 NEAREST MARKET ☐ 5 CENTRAL MARKET ☐ 5 OTHER SPECIFY: _____
C4a	To whom was the Rice Sold	☐ 1 RICE TRADERS IN THE VILLAGE ☐ 2 RICE TRADERS OUTSIDE VILLAGE ☐ 3 RICE CONSUMERS ☐ 4 ORGANIZATIONS ☐ 5 OTHER SPECIFY: _____
C4b	Are you satisfied with your level of commercialization of rice?	☐ 1 – YES ☐ 0 –NO

D. Factors that Determine Rice Commercialization

D1. Does the Household have access to Subsidized Fertilizers?
☐ 1 – YES ☐ 0 –NO
D1a. If yes, How many years have you had access to Subsidized Fertilizes? _____
D1b. Has the Climatic Conditions in this community affected the Commercialization of your Rice?
☐ 1 – YES ☐ 0 –NO
D1c. If yes, how has it affected
☐ 1 YIELD HAS INCREASED
☐ 2 YIELD HAS REDUCED
☐ 3 YIELD HAS REMAINED SAME
☐ 5 OTHER SPECIFY_____
D1d. How many bags of subsidized fertilizer did you use for rice production over the past 12 months?_____
D1e. If No Why?
☐ 1 – DON'T KNOW HOW TO GET ☐ 2 – DO NOT NEED SUBSIDIZED FERTILIZERS
☐ 3 – DIFFICULT TO GET ☐ 4 - OTHER SPECIFY

D2. Does the Household have access to Credit Facilities for Rice Cultivation?
☐ 1 – YES ☐ 0 –NO
D2a. If yes, where did you get the Credit?
1– COMMERCIAL BANK ☐ 2 – SAVINGS AND LOANS INSTITUTION ☐ 3 – INDIVIDUAL CREDITORS ☐ 4 – NGOS
D2b. If yes, how much credit did you obtain? _____GHS

D3. Do you have access to Extension services?
☐ 1 – YES ☐ 0 –NO
D3a. If yes, from whom do you get the Services?
1– MOFA ☐ 2 – NGO ☐ 3 – OTHER INSTITUTIONS
D3 How many extensions did you have over the past 12 months? _____

D4. Does the Household have access to subsidized improved seed?
☐ 1 – YES ☐ 0 –NO
D4 a. If yes, How many years have you had access to Subsidized Fertilizes? _____
D5. Do you have Ready Market for Rice?
☐ 1 – YES ☐ 0 –NO
D5 a. What is the distance from home to the Nearest Market Place_____(Miles)
D5b. Do you have Access to Public transport to the Nearest Market Place?
☐ 1 – YES ☐ 0 –NO
D5b. How much is transportation Cost (Including Vehicle Hiring) to the Nearest Market place _____GHS
D5c.What is the Most Common Means of Transportation to the Nearest Market?
1– TRICYCLE ☐ 2 – TRUCK ☐ 3 – MOTORBIKE ☐ 4 – BICYCLE ☐ 5 – WALK ☐ 6 – OTHERS_____
D6. Did this household receive remittance and other non-farm Income for the past 12 months?
☐ 1 – YES ☐ 0 –NO
D6 a. If yes, How Much did in Total did you receive?
D7. Do you own the House?
☐ 1 – YES ☐ 0 –NO

E. Household Consumption and Expenditure

Consumption from purchase, gifts and Own production of the household is the total household consumption.

Food Expenditure

Product Consumed		Consumed in the Last One Month(Y/N)	Quantity	Value per Unit(GHS)	Total Value(GHS)
E1	Cereals				
E2	Meat and Fish				
E3	Fruits				
E4	Roots and Tubers				
E5	Vegetables				

Non-Food Expenditure

Expense		Expended in the Last One Year(Y/N)	Total Value(GHS)
E6	School Fees		
E8	Medical Care		
E9	Shoes and Clothing		
E10	Utility Fees		
E11	Livestock feed		
E12	Others(specify)_____		

Asset Ownership

Product		Does HH Own (Y/N)	Quantity	Total Value(GHS)
E13	TV			
E14	Radio			
E15	Mobile Phone			
E16	Bicycle			
E17	Motorbike			
E18	Car/Vehicle			
E19	Storage Facility for Crops			
E20	Tractor			
E21	Livestock			

F. Support Services

F1. Do you have access to training on agricultural Practices?

☐ 1 – YES ☐ 0 – NO

F1a. If yes, who did the training?

☐ 0 – MOFA ☐ 1 – NGO ☐ 2 – INDIVIDUAL TRAINERS ☐ 3 – OTHERS_____

F1b. What have you learnt from the Training Programme, if yes?_____
_____
_____

F2. Do you Receive information Market Prices of Rice?

☐ 1 – YES ☐ 0 – NO

F2a. If yes, from which medium do you receive the information?

☐ 0 – FRIENDS ☐ 1 – RELATIVES ☐ 2 – MEDIA ☐ 3 – MOFA ☐ –NGO ☐ 4 –OTHERS_____

F2b. How Useful are the Price Information?

☐ 0 – VERY USEFUL ☐ 1 – USEFUL ☐ 2 – NEUTRAL ☐ 3 – NOT USEFUL

F3. Do you have an agricultural Research Station around this community?

F3a. If yes what is the Name?

F3b. Do you get some support from agriculture research institutes with regards to Rice?

☐ 1 – YES ☐ 0 – NO

F3c. If yes, what kind of support_____

F4. Do your household have the Necessary Finance for Rice Production?

F4a. What is your major source of Finance for Rice?

☐ 0 –OWN SAVINGS ☐ 1 – RELATIVES ☐ 2 – SAVINGS AND LOANS INSTITUTIONS ☐ 3 – ☐ –FRIENDS ☐-OTHERS_____

F5. DO YOU HAVE ANY COMMENT?

Appendix 2: **Rosenbaum Bounds for ATT (N = 419 Matched Pairs)**

Gamma (\u0393)	sig+	sig-	t-hat+	t-hat-	CI+ (Upper Bound)	CI- (Lower Bound)
1	0	0	59.8954	59.8954	54.3746	65.579
1.5	0	0	50.036	70.2958	44.6099	76.3501

Note:

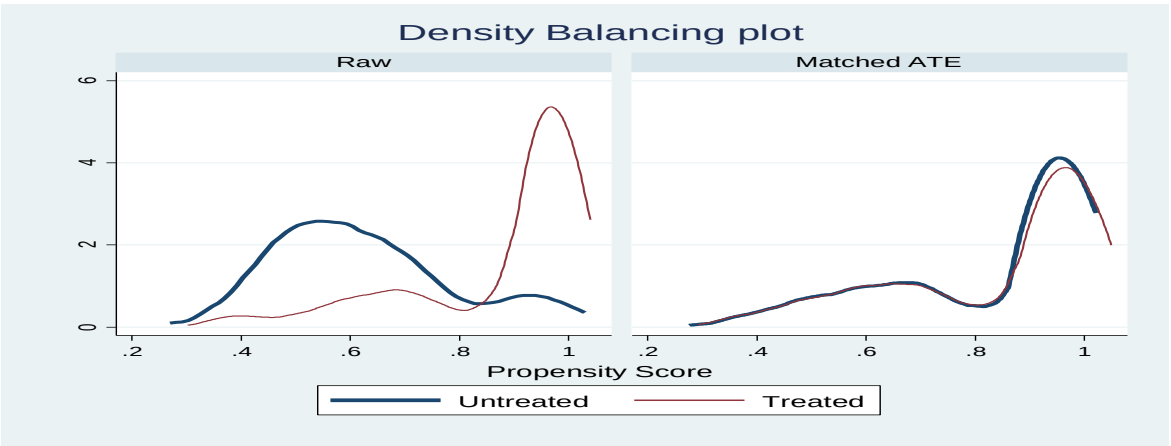
- **Gamma (\u0393):** Log odds of differential assignment due to unobserved factors.
- **sig+:** Upper bound significance level.
- **sig-:** Lower bound significance level.
- **t-hat+:** Upper bound Hodges-Lehmann point estimate.
- **t-hat-:** Lower bound Hodges-Lehmann point estimate.
- **CI+:** Upper bound of the 95% confidence interval.
- **CI-:** Lower bound of the 95% confidence interval.

Appendix 3: Post Estimation for Balancing (Propensity Score Matching)

```
Covariate balance summary
```

	Raw	Matched
Number of obs =	420	840
Treated obs =	351	420
Control obs =	69	420

	Standardized differences		Variance ratio	
	Raw	Matched	Raw	Matched
Radio_owned	.4258158	.0299321	.6221279	.9552239
Credit_support	-.055906	-.0453378	1.100086	1.087561
Remittances_a~e	-.3045899	.2036705	.8593407	1.198023
Age_of_Respon~t	.4838847	.1530376	1.72214	1.909196
Yrs_of_rice_f~g	.2681494	.0463649	1.594679	2.486056
Motorable_road	1.414285	.6088549	1.826895	1.116009
Extension_Con~t	.9255376	-.1183974	15.37714	.9073614



Appendix 4: Distribution of Respondents by District and Community

District	Community	Number of Respondents	Total
Sagnerigu	Ngarin	21	105
	Kukpehi	21	
	Dimali	21	
	Kpeni	21	
	Garizegu	21	
Savelugu	Zoggu	21	105
	Moglaa	21	
	Nabogu	21	
	Nyatua	21	
	Sandu	21	
Tolon	Fehini	21	105
	Kpalgun	21	
	Golinga	21	
	Gbulahig	21	
	Nyankpala	21	
Kumbungu	Voggu	21	105
	Gingani	21	
	Kpalsogu	21	
	Nawuni	21	
	Gupaneri	21	
Total		420	420

Appendix 5: Model Diagnostic Tests (Variance Inflation Factor (VIF) Test for Multicollinearity)

Variable	VIF	1/VIF
hhs	2.93	0.3413
Qty_mobile_phone	2.39	0.4176
Yrs_of_rice_farming	2.37	0.4227
Age_of_Respondent	2.29	0.4375
HH_Total_Land_Size	2.21	0.4533
FBO_membership	1.87	0.5341
Extension_Contact	1.76	0.5691
Motorable_road	1.63	0.6119
Distance_Home_to_Market	1.47	0.6785
Number_days_worked	1.45	0.6915
Number_Years_Schooling	1.39	0.7207
Motorbike_owned	1.38	0.7221
TV_Owned	1.34	0.7473
Access_Improved_Seeds	1.2	0.832
Radio_owned	1.19	0.8379
Lovestock_owned	1.19	0.8437
Sex	1.1	0.9066
Credit_support	1.09	0.9184
Mean VIF	**1.68**	-

Appendix 6: Receiver Operating Characteristic (ROC) Test for Model Accuracy

Probit Model for Rice Sold	Value
Number of Observations	420
Area Under ROC Curve (AUC)	0.9775

Appendix 7: Validity check of Instruments for Endogenous Switching Regression

Test	Statistic	Value	Conclusion
Relevance (First-Stage F-Test)	F (3, 416)	81.74	Instruments are strong (F > 10)
Instrument 1: Distance from Home to nearest market	t-stat	-10.71	Significant (p = 0.000)
Instrument 2: Motorable road	t-stat	6.06	Significant (p = 0.000)
Instrument 3: Access to Improved seeds	t-stat	2.42	Significant (p = 0.016)
R-squared (First-Stage Regression)	-	0.3709	Instruments explain 37.1% of variation in Rice Sold

Barnabas Kadiri Seidu

turnitin

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