THE EFFECTS OF OUTGROWER SCHEME ON LIVELIHOODS OF SMALLHOLDER SORGHUM FARMERS IN NORTHERN GHANA

BY

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DECLARATION

I, Charles Kwowe Kwame Nyaaba, do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled, "The Effects of Outgrower Scheme on the Livelihoods of Smallholder Sorghum Farmers in Northern Ghana" is the result of my own research. This thesis has never been presented either in whole or in part for any other degree of this University or elsewhere.

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DEDICATION

This thesis is dedicated to the members of Peasant Farmers Association of Ghana (PFAG).

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ABSTRACT

Outgrower scheme (OGS) is widely articulated as an ideal option that can deal with subsistence farming practices of smallholder farmers (SHF) to approach their farming as a business. For OGS to attract SHF participation and lead to livelihoods enhancement, this study argues for strengthening extension services, guaranteed market and promotion of FBO formation as part of the OGS support to farmers. The study also advocates for integration of climate change mitigation services as part of the OGS package. The study combined quantitative and qualitative research methods to analyse the effects of OGS on the livelihoods of smallholder sorghum farmers in Northern Ghana. Specifically, the study examines factors influencing SHF participation in the OGS, the effects of OGS on their productivity, profitability, postharvest loss (PHL) and their vulnerability to climate change. The multistage sampling procedure was used to collect quantitative data from 516 sorghum outgrower farmers (treatment) and non-outgrower farmers (control) groups in Garu and Jirapa districts in the Upper East and Upper West regions of Ghana respectively. Using the probit regression model to determine factors influencing SHF participation in OGS, the results pointed to belonging to FBO, access to market and access to extensions services as key determinants. The study also found average productivity of 1,207kg/ha, profitability of GHS 270/ha and post-harvest losses (PHL) of 14% for the treatment group. For control group, the average productivity was 820kg/ha, profit losses of GHS 92/ha and PHL of 27%. The study further found the treatment group to be relatively vulnerable to climate change than the control group with their overall aggregate livelihood vulnerability index (LVI) of *0.393* and *0.386* respectively. (LVI closer to 1 denotes highly vulnerable). Using endogenous switching regression model (ESRM) to establish treatment effect of OGS on SHF, the results suggest positive effects of OGS on productivity, PHL and profitability of resourced endowed farmers than ordinary SHF. On vulnerability to climate change, participation in OGS have minimal effect of climate change on SHF in the study areas. To stimulate SHF participation in OGS, the study recommend improvement in market access, extension services and establishing and strengthening the existing FBOs. Finally, to help improve SHF productivity, reduce their PHL and increase their profitability, the study recommends modification of the current OGS to make it more pro-poor and also, policies that will incentivize private sector to engage SHF on OGS that are pro-poor. For OGS to become more sustainable and contribute to reducing SHF vulnerability to climate change, the study suggests inclusion of climate change support variables as part of the OGS support to farmers.

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LIST OF ACRONYMS

1D1F	One District One Factory
1D1W	One District One Warehouse
1V1D	One Village One Dam
AAGDS	Accelerated Agricultural Growth and Development Strategy
AGRA	Alliance for Green Revolution in Africa
ATT	Average Treatment Effect on the Treated
ATU	Average Treatment Effect on the Untreated
CAADP	Comprehensive Africa Agriculture Development Programme
CAPI	Computer-Assisted Personal Interviewing
ECOWAP	Economic Community of West African States Regional Agricultural Policy
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
ESR	Endogenous Switching Regression
ESRM	Endogenous Switching Regression Model
EUCORD	European Cooperation for Rural Development
FAO	Food and Agriculture Organisations of United Nations
FASDEP I	First Food and Agricultural Sector Development Policy one
FASDEP II	Second Food and Agricultural Sector Development Policy II
FIML	Full Information Maximum Likelihood Estimate
GCAP	Ghana Commercial Agricultural Programme
GDP	Gross Domestic Product
GGBL	Guinness Ghana Brewery Limited
GhAIP	Ghana Agricultural Investment Plan
GLSS	Ghana Living Standard Survey
GOPDC	Ghana Oil Palm Development Company Limited
GPRS I	First Ghana Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
IPCC	Inter-Governmental Panel on Climate Change

IPWRA	Inverse Probability Weighted Ratio Adjusted
ISSER	Institute of Statistical, Social and Economic Research
MDGs	Millennium Development Goals
METASIP I	First Medium-Term Agricultural Sector Investment Plan
METASIP II	Second Medium-Term Agricultural Sector Investment Plan
MoFA	Ministry of Food and Agriculture
NEPAD	New Partnership for Africa Development
NGO	Non-Governmental Organisations
OGS	Out Grower Scheme
OLS	Ordinary Least Square
PERD	Planting for Export and Rural Development
PFJ	Planting for Food and Jobs
PHL	Post Harvest Loss
PSIA	Poverty and Social Impact Analysis
PSM	Propensity Score Matching
SARI	Savanna Agriculture Research Institute
SDGs	Sustainable Development Goals
SHF	Small Holder Farmer
SLF	Sustainable Livelihood Framework
SOGS	Sorghum Out Grower Scheme
SSA	Sub-Saharan Africa
TH	Transitional Heterogeneity
TZ	Tuozafi
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WASVCD	West African Sorghum Value Chain Development Project

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

There is global consensus on agricultural contribution to poverty reduction, job creation and overall economic development (Alexandratos & Bruinsma, 2012; Schaffnit-Chatterjee, 2014). The Food and Agriculture Organisations of the United Nations (FAO) (2018) identified strategic agricultural investment in Sub-Saharan Africa (SSA) as an important option that can increase incomes of smallholder farmers (SHF), reduce their poverty level and at the same time, guarantee enough food for the projected global population of 9.8 billion people by 2050. In analysing challenges and opportunities in agricultural investment in SSA, Saghir & Hoogeveen (2017) found effects of investing in the agricultural sector as eleven times effective in reducing poverty than similar investments in the other sectors of the SSA economy.

In Ghana, the agricultural sector play a leading role in the overall economic development. The sector provides jobs for about 38.3% of the population and remain the major sources of income for majority of low income earners, largely, those in the rural areas (Ghana Statistical Service (GSS), 2019). According to GLSS 7 report, about 63.3% of rural folks are engaged as skilled agricultural workers compared to 11.4% for those in the urban areas.

Several literature identified SHF constraints such as difficulty in accessing financial support; access to mechanization services; reliance on outmoded method of farming; poor extension services; poor market and storage infrastructure; high postharvest losses (PHL); limited irrigation facilities and effects of climate change as a major challenge for SHF development in Ghana (Awunyo-Victor & Al-hassan, 2014; Boateng & Nyaaba, 2014; Dittoh & Akuriba, 2018; FAO, 2017; GSS, 2014d; Intergovernmental Panel on Climate Change (IPCC), 2013; MoFA, 2017b; Villano, Asante, & Bravo-Ureta, 2019).

Smallholder farmers productivity in Ghana as is the case for most SSA countries is generally low, production is limited to home consumption and surpluses for the market (Ecker, 2018). They are classified among the poor in the country (GSS, 2019). To improve the livelihoods of SHF will require a strategy that will transform their current subsistence farming practices to approach their farming as a business.

Ghana government response to addressing SHF constraints is articulated in the Food and Agricultural Sector Development Policy I and II (FASDEP I &II) and associated first and second Medium-Term Agricultural Sector Investment Plans (METASIP I and II) (Allience for Green Revolution in Africa (AGRA), 2016; Ministry of Finance, 2018; MoFA, 2017b). Some programmes in METASIP II implemented in support of SHF include: Fertilizer and Seed Subsidy Programme, Creation of Agricultural Mechanization Centres and establishment of National Food Buffer Stock Company (Fearon & Adraki, 2015; Institute of Statistical, Social and Economic Research (ISSER), 2012; World Bank, 2012). With all these interventions, data from the Ministry of Food and Agriculture (MoFA) shows little improvement in SHF performance which reflect the stagnation of productivity of various staples in Ghana (Ministry of Food and Agriculture (MoFA), 2017a). Table 1.1 shows actuals yields and achievable yields of some selected staple crops of SHF in Ghana.

Table 1.1: Actual and Achievable Productivity of Major Staple Crops in Ghana

Staple crops	Achievable yield (MT/ha)	Actual yield (MT/ha)	% Achieved
Maize	5.50	2.05	37.27
Rice (Paddy)	6.00	3.01	50.17
Cassava	45.00	20.68	45.96
Yam	52	16.74	32.19
Sorghum	2.00	1.24	62.00
Soybeans	3.00	1.70	56.67

Source: MoFA, 2017

1.1.1 Smallholder Farmers and Sorghum Production in Ghana

The concept of SHF varies from different literature. From a general standpoint, SHF are farmers operating under structural constraints such as access to sub-optimal amounts of resources, technology and markets (Dittoh & Akuriba, 2018; Dixon *et al.*, 2004) summarize this idea when they say that "the term smallholders refers to limited resource endowment of farmers compared to other farmers in the sector". In Ghana, Ministry of Food and Agriculture categorised SHF as those cultivating a land area below two hectares (MoFA, 2016). For the purposes of this study, sorghum smallholder farmers are sorghum farmers who cultivate less than two hectares, are constraint with production and marketing resources and hardly access quality extension services.

Sorghum is a staple crop predominantly cultivated by SHF in Northern Ghana. It is largely grown in the Sudan and Guinea Savanna agro-ecological zones of Ghana (Akuriba & Asuming-Brempong, 2012). Sorghum farming is said to be convenient due to its low inputs' requirements, less laborious and has the ability to withstand the unfriendly weather condition in Northern Ghana. Sorghum can be grown in any marginal lands without heavy fertilizer application (Angelucci, 2013).

Every part of the sorghum plant has economic value. Sorghum can be used for preparation of light porridge and *tuozafi* (TZ). *Tuozafi* has become a staple food in Ghana, especially among the indigenes of Northern Ghana. The flour of sorghum serves critical needs such as curing illnesses and feeding lactating mothers. Sorghum leaves and stalks are used for fencing, weaving baskets, roofing, mat making and also fuel for cooking in most rural areas in northern Ghana (Angelucci, 2013; Ratnavathi *et al.*, 2016). The fresh sorghum leaves and stalks as well as processed sorghum grains are good for feeding livestock (Angelucci, 2013). During festivals, funerals and other formal and informal social gatherings, sorghum artisanal beer popularly called *pito* is widely consumed in Ghana (Djameh *et al.*, 2015). Guinness Ghana Brewery Limited (GGBL) has discovered sorghum as perfect substitute for barley since 2006 (Angelucci, 2013; Guinness Ghana Brewery Limited (GGBL), 2017). According to GGBL (2017), with better production and marketing arrangement, sorghum farming can create jobs in northern Ghana and subsequently, lead to reduction of migration of the youth to southern Ghana in search of non-existing jobs.

Sorghum has been substituted for barley by GGBL for the brewing of alcoholic and non-alcoholic drinks. According to GGBL (2017), the company policy to source local raw materials including sorghum for their beverage production is expected to create market, create jobs and alleviate poverty among the producers who are prodominately SHF. Subsitituting imported barley to sorghum has also reduced the import bill and contributed to stabilizing the local currency (GGBL, 2017; Sarfo-Mensah, 2017)

1.2 Problem Statement

Agriculture play significant role in socio-economic development of Ghana contributing about 21.2 per cent of gross domestic product (GDP) and providing a major source of income and employment for most households (GSS, 2019; Ministry of Finance, 2019). Ghana's agricultural sector just like other SSA countries, is dominated by SHF who constitute over 80 percent of food crop farmers (Villano *et al.*, 2019). Their land holdings are between one to two hectares (SRID, 2017). Most of them still depend on outmoded technologies in farming (AGRA, 2017; Chauvin *et al.*, 2012; Ecker, 2018). Other challenges are their inability to access quality inputs, credit and extension services leading to low crop yields, low productivity reflecting in their low profitability. Smallholder farmers are also challenge with guaranteed market and profitable prices (Mariano *et al.*, 2012; Tsinigo & Behrman, 2017; Al-Hassan *et al.*, 2013; Ecker, 2018).

Poor agronomic practices coupled with poor postharvest facilities, smallholder farmers are also face with high PHL (Kiaya, 2018). The high PHL is usually due to poor postharvest facilities such as, harvesters, dryers, appropriate transport facilities and storage infrastructure (Affognon *et al.*, 2015; Sheahan & Barrett, 2016).

Aside the above challenges, access to market is a major challenge facing several farmers in Ghana including those cultivating sorghum. Availability of market has become a key determinant of the choice of crop produced (Ebata & Hernandez, 2017; Opoku, 2012). In recent times, sorghum cultivation has attracted the interest of many SHF in northern Ghana due to huge demand of sorghum from GGBL for brewing of alcoholic and non-alcoholic beverages (Angelucci, 2013; Sarfo-Mensah, 2017). Whiles GGBL marketing arrangement contributed to addressing marketing challenges of sorghum in Ghana, the call for provision of market for sorghum is still high due to GGBL targeting farmers who produced under GGBL promoted outgrower schemes (Angelucci, 2013). According to Sarfo-Mensah 2017, "some sorghum farmers are still unable to access market from GGBL due to their inability to produce quality sorghum that meets GGBL quality requirements". Access to market is not only available market, but also market that offers profitable prices (Ebata & Hernandez, 2017)

Similar to the general problems confronting other food crop producers, sorghum farmers have to also struggle to access optimal inputs, quality extension services, quality postharvest facilities, credit and also, suffer with poor weather conditions (Azumah *et al.*, 2016; Tsinigo & Behrman, 2017; Udimal *et al.*, 2017).

Majority of sorghum farmers use poor quality seeds for planting and hardly follow good agronomic practices leading to low crop yields. Harvesting is done manually using simple farm tools such as hoes and cutlasses. The harvested grains in most occasions are dried on the field and threshed manually (Akuriba & Asuming-Brempong, 2012; Statistics, Research and Information Directorate of Ministry of Food and Agriculture (MoFA-SRID), 2016). These practices apart from reducing the yield quality and quantity, also lead to high postharvest losses. In Ghana, high PHL loss, especially aflatoxin contamination in sorghum is of major concern. Available statistics put PHL in sorghum between 5% to 15% (High Level Panel of Expert on Food Security and Nutrition (HLPE), 2014; MoFA, 2016).

Another constrain to sorghum production is the effect of climate change. Intergovernmental Panel on Climate Change opines that climate related hazards affects the livelihoods of rural poor directly by affecting their crop yields and worsening their food insecurity situation (Intergovernmental Panel on Climate Change (IPCC), 2018). The changes are in the form of low and unpredicted rainfall, rising temperatures, flooding, drought and emergence of pest and diseases (Adu *et al.*, 2018; Dickinson *et al*., 2017; IPCC, 2018; Jamshidi *et al.*, 2019; Makate *et al.*, 2019; Makuvaro *et al.*, 2018; Shah *et al*,. 2013; Yaro, 2013). These challenges have drastically affected smallholder farmers productivity, PHL and their profitability.

The combined effects are reduction in sorghum production, slow growth of sorghum production and reduction in sorghum contribution to agricultural GDP (MoFA-SRID, 2016). Figure 1.1 shows the trend of sorghum production, area planted, annual production and annual growth for the period of 2005 to 2016. The area planted, annual production and annual growth has experienced increment from 2007 to 2008 and declined after 2008 (Figure 1.1).

Figure 1.1: Trend of Sorghum performance for the Period of 2005 to 2016

Sources: SRID (2017)

Given the important role of sorghum to socio-economic development in Northern Ghana and also the consistent decline in the overall performance, any government policy direction to support sorghum production and marketing could contribute to overall wellbeing of farmers. some programmes implemented by governments over the years to modernise the activities of SHF are captured in FASDEP II and METASIP II (MoFA, 2015). These programmes include: Fertilizer and Seed Subsidy Programme implemented to reduce cost of fertilizer and seeds for easy access. The programmes were expected to lead to improvement in application of fertilizer and improved seeds (Fearon & Adraki, 2015), establishment of Agricultural Mechanization Centres expected to reduce difficulty of SHF farmers access to mechanization services, establishment of National Food Buffer Stock Company expected to provide guaranteed prices and market for grains, construction of warehouses in every district to help address the problem of access to storage facilities and instituting Ghana Commodity Exchange programme to provide storage facilities, credit, market access and profitable prices (MoFA, 2007, 2015, 2017a).

In 2017, the government of Ghana took another bold step to support SHF by introducing Planting for Food and Jobs (PFJ). The PFJ provided farmers with subsidised fertilizer, seeds, extension services and market access with the aim of modernizing their activities, addressing food security constraint and creating jobs (MoFA, 2017b). Even though limited assessment reports on these interventions exist, there is no evidence of SHF modernization and increased in crop productivity in Ghana.

Inability of government to modernize the activities of SHF and to alleviate them from their current subsistence farming to market-oriented agribusiness call for alternative approach in handling government interventions. Several studies shows evidence of potentials of OGS to modernize the activities of SHF and improve their production efficiency (Minot, 2011; Agbelengor, 2015; Maertens & Velde, 2017; Ton *et al.*, 2017; Ragasa *et al.,* 2018) . The benefits of OGS ranges from helping SHF to access credit, provision of quality inputs (fertilizer and seeds), provision of mechanization services, provision of extension services and guaranteed market (Barrett *et al.*, 2012; Minot & Ronchi, 2014; Minot, 2015; Maertens & Velde, 2017). The extension services as part of OGS package also provide farmers with climate information, early warning system and climate resilient crop varieties (Feleke *et al.,* 2017; Ghimire *et al.,* 2015; Uaiene *et al.,* 2009).

Regardless of the optimism about the prospects of OGS in modernizing the activities of SHF and transforming them to market oriented agribusiness entrepreneurs (Barrett *et al.,* 2012; Maertens & Velde, 2017; Minot, 2015; Minot & Ronchi, 2014; Paglietti & Sabrie Roble, 2012), other studies such as Oya (2012); Wang *et al.* (2014), Otsuka *et al.* (2016) and Vicol (2017) are pessimistic about the real benefits of OGS to SHF and raised concerns of buyers unilaterally determining quality standards, prices, cost of inputs and repayment terms leading to low benefits and high exit rate among most schemes.

Vicol (2017) case study of potato outgrower scheme in Maharashtra, India for instance, argues that rather than an inclusive alternative to land grabbing, outgrower scheme represents another form of land grabbing in rural India. According to the study "while some individual households have improved their livelihoods through participation, the scheme acts to reinforce already existing patterns of inequality". The study concluded that, "the unequal power relations between firms and farmers skew the capture of benefits towards the firms, and render participating households vulnerable to indebtedness and loss of autonomy over land and livelihood decisions".

Most OGS studies in Ghana such as Agbelengor (2015); Torvikey *et al.* (2016) and Paglietti & Sabrie Roble (2012) are all on high valued cash crops usually produced in southern Ghana by medium to large scale farmers. The sorghum crop has dual role as staple food crop and now industrial cash crop and is mainly cultivated by SHF in Northern Ghana. The few studies on staple crops in Ghana such as Ragasa *et al.* (2018) on limitation of maize contract farming as a pro-poor strategy in the Upper West Region of Ghana and Brigitte & Ragasa (2018) on effect of contract farming on development projects and private sector activities in Northern Ghana and also, Maertens & Vande (2017) on rice in Benin. Whiles these studies focus on productivity and profitability, information on postharvest losses and vulnerability to climate change is ignored. In terms of appropriateness of the methodology adopted, the methods used were robust and appropriate for the context. However, Ragasa *et al.* (2018) study on maize cannot be used for policy making for sorghum due to numerous government support and available market for maize in Ghana. Also, Brigitte & Ragasa (2018) study was comparing effect of development projects on private projects and did not analyse the effect on livelihoods. Concerning Maertens & Vande (2017) study on rice, apart from substantial differences between sorghum and rice in terms of utilization, government support and available market for rice, geographical location and country specific characteristics weaken any justification for policy making in Ghana based on the Maertens & Vande (2017) work. Whiles Maertens & Vande (2017) and Ragasa *et al.* (2018) work provided information on effects of outgrower scheme on profitability for rice and maize farmers respectively, information on effects on PHL and vulnerability to climate change was ignored.

Other studies such as Azumah *et al.* (2016) to determine the factors influencing SHF decision to participate in OGS and its effect on farm income in the Northern Region of Ghana found that access to credit and extension services positively influenced farmers decision to participate (Azumah *et al.*, 2016). The Azumah *et al.* (2016) study did not target specific crop which defeats the concept of OGS.

Given the importance of sorghum production to the livelihoods of SHF in Northern Ghana and lack of empirical study on its effect and also, the inability of government interventions to improve smallholder sorghum farmer's performance, information on programmes and interventions that can transform their subsistence farming practices to agribusiness will be relevant for policy making. This research therefore examines whether OGS has any effects on the livelihoods of smallholder sorghum farmers in Northern Ghana or not. Specifically, the study will answer the following research questions:

i. What factors influence smallholder farmers' decision to participate in sorghum outgrower scheme?
ii. What are the effects of outgrower scheme on smallholder sorghum farmers' productivity, postharvest loss and profitability?
iii. What are the effects of outgrower scheme on smallholder sorghum farmers' vulnerability to climate change?

1.3 Objectives of the Study

The main objective of the study is to examine the effects of outgrower scheme on the livelihoods of smallholder sorghum farmers in Northern Ghana. The specific objectives are to:

i. Determine factors influencing smallholder sorghum farmers' decision to participate in the outgrower scheme.

ii. Establish the effects of outgrower scheme on smallholder sorghum farmers' productivity, postharvest loss and profitability.

iii. Determine the effects of outgrower scheme on smallholder sorghum farmers' vulnerability to climate change.

1.4 Hypothesis of the Thesis

The main hypotheses of the thesis are:

1. Household characteristics, farm and market characteristic, socio-economics and political characteristics significantly influence smallholder farmers' decision to participate in sorghum outgrower scheme.

2. Sorghum ourgrower scheme enhances smallholder farmers' productivity, helps reduce their postharvest losses and increases their profitability.

3. Sorghum ourgrower scheme reduces smallholder farmers' vulnerability to climate change.

1.5 Relevance of the Study

This study is relevant because it provides information on factors influencing SHF decision to participate in SOGS in Northern Ghana. Knowledge on factors influencing SHF decision to join outgrower scheme is important information that can inform policy makers on the type of policies that can improve the sorghum industry. Given the uniqueness of sorghum as staple crop and now industrial crop and also the complex nature of SHF engaging in cash crop production, understanding the specific factors motivating their decision to participate is relevant for policy making.

Secondly, information on effects of OGS on SHF farmers' productivity, postharvest loss and their profitability is important information for both private sector and government investment decisions. Existing literature on OGS on staple crops focus only on productivity and profitability. Information on postharvest losses and SHF vulnerability to climate change has always been ignored of which this study provides.

Another important dimension of this study is to understand the effects of outgrower scheme on SHF vulnerability to climate change. Climate change and its impact on livelihoods is of global concern and most previous studies focuses only on farm level adaptation strategies. Evidence on the effects of OGS on vulnerability to climate change will help policy makers to take investment decisions on OGS development in Ghana.

Following the government policy decision to develop Ghana beyond, various flagship programmes were implemented in the agricultural sector. These programmes aimed at enhancing SHF performance, promoting government modernization agenda and consequently leading to food security and job creation. Given that similar projects such as the establishment of Agricultural Mechanisation Centres, National Food Buffer Stock Companies and Fertilizer Subsidy programmes in the past failed to achieve project objectives, evidence on effects of SOGS could serve as a learning curve to guide government on future investment decisions.

Finally, there are limited empirical literature on SOGS in Ghana. The few existing literature are end of project evaluation reports. The methodology adopted by such studies are not robust and policy recommendations from such reports are not scientifically proven. Using information from such reports for policy formulation could be misleading and leading to weak policies.

This study employed Endogenous Switching Regression Model (ESRM) which address heterogeneity and endogeneity problems leading to unbiased and consistent results. Recommendations based on consistent and unbiased results will generate debate that will resonate beyond academic cycles to ideal policies that have positive impact on the beneficiaries.

1.6 Organisation of the Thesis

The thesis is broadly organised in five chapters. Chapter one contains background information of the study, problem statement, objectives of the study, relevance of the study and organization of the thesis. Chapter two reviewed literature on SHF and their livelihood situation, their constraints, their productivity, their PHL and their vulnerability to climate change. Literature on OGS and its livelihood implications to SHF were also reviewed. Other areas that were reviewed in chapter two were agricultural policies and investment plans and Ghana government agricultural flagship programmes. The last part of chapter two summarises the literature and present important issues identified in the literature. Chapter three is about the conceptual framework of the study, theoretical framework, data sources and sampling procedure. Information on the study area and methods of data analysis were also discussed. Chapter four contain the results and discussions. Chapter five is the summary of the study, conclusion, policy recommendations and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the relevant empirical literature on outgrower schemes. The chapter is organized into sections as follows. Section 2.2 background of sorghum production and sorghum ourgrower scheme in Ghana. Section 2.3 reviews literature on agriculture and economic development in Africa and that of Ghana in food and agricultural policies. 2.4 Ghana government's agricultural flagship programmes. Section 2.5 contains contextual issues surrounding smallholder farmers, their livelihood situation, their production, postharvest losses and climate change issues. Section 2.6 review literature on outgrower schemes Section while section 2.7 summarises the literature and identifies literature gaps.

2.2 Background of Sorghum Production

Sorghum farming in recent times attracted global attention due to discoveries on its nutritional values and the comparative advantage it has in the brewing industry to other crops (Ramashia *et al.,* 2019). Among cereal crops consumed by humans, sorghum ranked third only superseded by wheat and rice in Africa, China and India (Hariprasanna *et al.,* 2015; Ramashia *et al.,* 2019). Some of the north-eastern countries in China such as Jilin, Liaoning, and Heilong-jiang have rice-like sorghum food as their major diet (Upadhyaya *et al.,* 2017).

United States, Australia, and Argentina account for 20%-30% of the world sorghum and top the sorghum exporting countries (Mccuistion *et al.,* 2019). According to Ratnavathi *et al*. (2016), the unique attributes of sorghum as a drought-tolerant crop, grown in any marginal lands, requiring lesser inputs in production and climate-resilient makes it suitable crop for the poor. Utilization of sorghum as snacks, cookies and noodles are on the increase in Japan, the United States of America and Vietnam. Consumption of gluten-free beers prepared from sorghum are currently on the increase in America to cater for celiac patients (Aruna & Visarada, 2018). According to Aruna & Visarada (2018), special sorghum varieties are produced for direct consumption and for preparation of various snacks and weaning foods in India.

In Africa, several meals such as porridge, steam-sorghum and snacks are prepared from sorghum and are delicacy for most rural and urban populations in many countries in the continent (Djameh *et al.,* 2015; Upadhyaya *et al.,* 2017). Couscous (grain like meal, prepared from sorghum flour) for example, is a granulated and steamed traditional food preferred in many parts of SSA, especially Senegal but originated from North Africa (Ramashia *et al.,* 2019). Injera (crepe-like spongy bread made from sorghum) of Ethiopia, Kisra from Sudan is thin fermented bread prepared with sorghum, Ogi from Nigeria is fermented cereal pudding made of sorghum and gluten-free breads from Nigeria are some of the important food prepared using sorghum in SSA (Djameh *et al.,* 2015; Upadhyaya *et al.,* 2017). Also, lager and stout beer known as clear beer is brewed through malting of sorghum in Nigeria (Aruna & Visarada, 2018; Ogunsakin *et al.,* 2017; Ramashia *et al.,* 2019; Upadhyaya *et al.*, 2017)

Sorghum ranked third among important cereal crops grown in Ghana after maize and rice, with a share of 12% of the total cereal production (Akuriba & Asuming-Brempong, 2012; Angelucci, 2013) The popular sorghum varieties grown in Ghana are Naga White, Naga Red, Kapaala, and Dorado. Sorghum is considered a climate tolerant crop, easy to cultivate, requires low fertilizer application and can be cultivated on any marginal lands. It is considered in recent times as a cash crop of which majority of the youth in northern

Ghana are engaged as economic activity (Akuriba & Asuming-Brempong, 2012; Djameh *et al*., 2015).

Apart from food security and income, the value of sorghum is associated with social, cultural and religious ceremonies. The leaves and stalks are used for fencing, weaving baskets, roofing, mat making and also fuel for cooking in most rural areas in northern Ghana. Sorghum also serves critical needs such as curing illnesses, feeding lactating mothers and serving as delicacies for many households in rural northern Ghana (Angelucci, 2013; Ratnavathi *et al.,* 2016). The GGBL discovered sorghum as a perfect substitute for barley and as part of their local resource used policy, sorghum demand by GGBL for brewing has increased (Sarfo-Mensah, 2017). According to Sarfo-Mensah (2017), sorghum production has attracted majority of farmers in northern Ghana through the GGBL SOGS. Despite the importance of sorghum production, there is no empirical literature on its livelihood's implications

2.2.1 History of Sorghum Outgrower Schemes in Ghana

The sorghum OGS in Ghana has its roots from European Cooperation for Rural Development (EUCORD) project, titled *"West African Sorghum Value Chain Development"* (WASVCD) which was launched in 2006. The project's aim was to develop high-quality sorghum supply chain in West Africa to become a substitute for barley. Ghana and Sierra Leone were the pilot countries with initial funding of US$ 2,897,000 for 60 months (European Cooperation for Rural Development (EUCORD), 2008; Paglietti & Sabrie Roble, 2012).

According to EUCORD (2008), the stakeholders for the project in Ghana were Technoserve who played the lead role in managing and coordinating the activities of all the other stakeholders; GGBL the end-user providing guaranteed market; Nucleus

Farmers, SHF, Outgrowers and Large-Scale Individual Farmers being the main producers; Credit Venture Capital Fund and Sinapi Aba Savings and Loans companies were the financial institutions providing monetary support; Dizengoff Ghana Ltd supporting with agro-inputs such as fertilizer and weedicides and training on safe use of agrochemicals; Savannah Agricultural Research Institute (SARI) for agronomic support and varietal release and Nasia Rice Company providing storage facilities. The project led to an increase in sorghum production in the target communities from 112, MT in 2005/6 to 904 MT in 2006/7 and again, to 1,272 MT in 2007/8. The number of participating farmers also increased from 900 in 2005/6 to 3,210 and 5,670 in 2006/7 and 2007/8 respectively. After exit of this project, many companies and individuals engaged sorghum farmers in the Upper East, Upper West and Northern Region with GGBL still being the end-user providing guaranteed market.

The structure of SOGS today comprises of SHF and medium to large scale farmers whose primary role is production. There are buyers popularly called aggregators buying from groups of farmers and supplying to big suppliers also called off-takers. The off-takers comprises of limited liability companies and Non-Governmental Organization (NGO) who signed contracts with GGBL. These actors deal with farmers directly by supporting them with inputs and other technical services to improve the quantity and quality of sorghum to meet the requirements of GGBL. They also support farmers with weather information and supply them with early maturing sorghum seeds to reduce the impact of climate change on their farming activities (Angelucci, 2013; Paglietti & Sbrie Roble, 2012).

2.3 Agriculture and Economic Development in Africa

Agriculture plays an important role in the socio-economic development of almost all countries in Africa (FAO, 2015; Saghir & Hoogeveen, 2017; AGRA, 2018; Ecker, 2018).

Its role ranges from poverty reduction, food security, job creation, boosting intra-Africa trade, rapid industrialization, sustainable resource and environmental management, economic diversification, shared prosperity and human security (AGRA, 2018; FAO, 2018; New Partnership for Africa Development (NEPAD), 2013). In reviewing prospects and challenges of Africa agriculture performance, FAO (2018) reported 53% of the 718 million total rural population in Africa as earning direct employment in the agricultural sector. The sector contributes 15% to Gross Domestic Product (GDP) on average, but the contribution varies widely across countries from under 3% in Botswana and South Africa to over 50% in Chad (NEPAD, 2013).

Majority of the sector's players are SHF who produce most of the food for domestic consumption and for export (AGRA, 2018). About thirty-three million farms of less than 2 hectares per household exist in Africa (FAO, 2018). Irrespective of their numbers, SHF often do not harvest enough food for home consumption and for the market due to inadequate access to productive resources. Catalysing the activities of SHF has greater potentials to enhance rural development which is fundamental for the attainment of the Sustainable Development Goals (SDGs) in Africa (AGRA, 2018; FAO, 2017).

There are several empirical literatures linking market imperfection to the inefficiency of SHF (AGRA, 2017, 2018). AGRA (2017) reported general poor crop yields among SHF in SSA and associated agricultural growth in the last three decades to area expansion. This type of growth is said to be unsustainable due to consistent decline in farm lands as a result of population growth (AGRA, 2017). According to FAO (2017), yield improvement base on crop intensification practiced in the developed countries is more sustainable and should be adopted by policy makers in SSA.

To improve their household incomes and mitigate consumption risks, SHF in most SSA countries rather adopted the option of diversifying their economic activities to include non-farm activities such as trading, animal rearing and agro-processing (Snyder *et al.*, 2015). The production constraints of SHF is likely to impact on their nutrition, food security and undernourishment among many households. Despite being reduced from the 1990-92 figure of 33% to 23% in 2014-16, the absolute number of undernourished people in SSA remains relatively high (FAO, IFAD, & WFP, 2015). In absolute numbers, the undernourished people in SSA has increased from 44 million in 2014 to 218 million in 2018 (AGRA, 2018; FAO, 2018).

The huge opportunities in the agricultural sector to change the fortunes of the continent has not been fully harnessed. Apart from the few commercial agriculture projects covering a relatively small share of crop production that practiced an improved method of farming, proper application of improved farming practices among SHF is much lower (Gandhi, 2014; Koira *et al.*, 2014). Increasing population leading to limited land for a fallow period which has been the normal practice of Africa farmers to replenish their depleted soils and also a limited public investment in SHF threatened the sustainability of SHF crop productivity (AGRA, 2018; Ecker, 2018; FAO, 2015, 2018; Saghir & Hoogeveen, 2017). Despite the importance of SHF in ensuring food security in SSA, the focus of policies are usually on large scale industrial agriculture (FAO, 2018). Deeper thinking to unmask unexploited approach of transforming the activities of SHF is required for agricultural transformation that can impact on the SDGs in Africa.

2.3.1 Agriculture and Economic Development in Ghana

The agricultural sector plays an important role in the socio-economic development of Ghana. The sector leads in provision of food, raw materials for industry, job creation and foreign exchange earnings(GSS, 2019). According the GLSS 7 report, the agricultural sector engages about 38.3% of the employed labour in Ghana compare to the services and industry sector of 43.5% and 18.2% respectively. More rural dwellers of about 65.2% are employed in the agricultural sector compare to the urban dwellers of 11.8% (GSS, 2019). The agricultural sector in Ghana is divided into five sub-sectors. The crops, fisheries, livestock, cocoa and forestry/logging (figure 2.1).

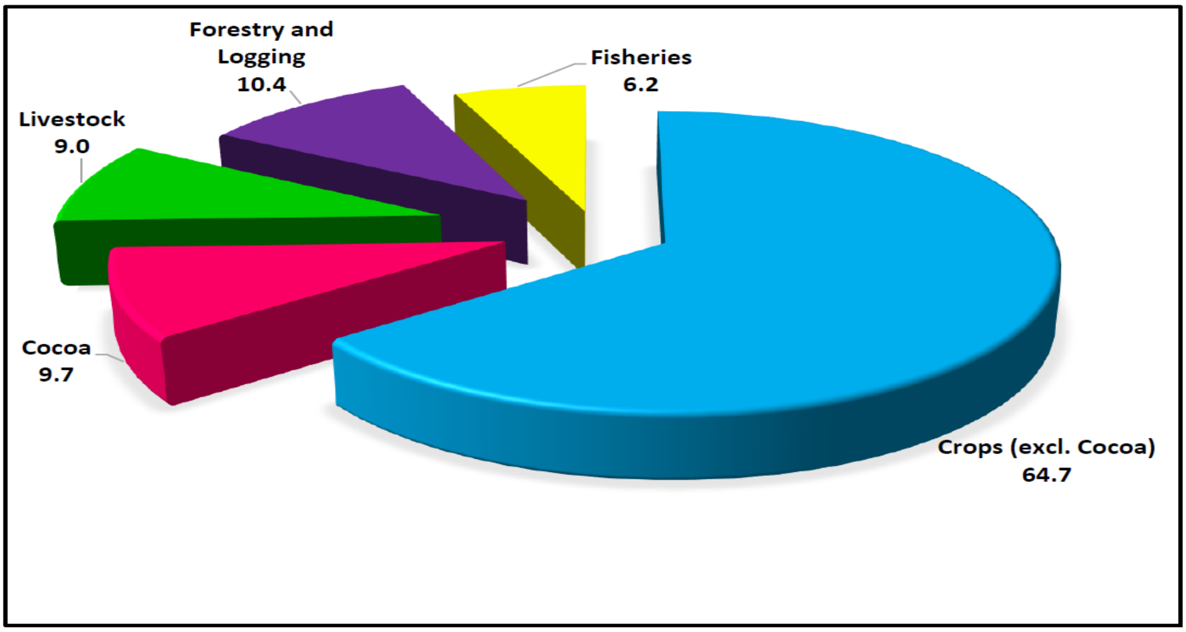

Figure 2.1: Agricultural Sub-Sectors in Ghana

Source: MoFA (2017)

The Ministry of Food and Agriculture (MoFA) is the lead ministry responsible for livestock and the crops sub-sectors which happened to be the largest among all the sub-sectors (Ministry of Finance, 2018). The MoFA is also the lead government agency responsible for coordinating agricultural activities among the various ministries and other non-governmental organisations and is given the mandate to develop and execute policies and programmes within agriculture development agenda.

Ministry of Fisheries and Aquaculture Development is responsible for the fisheries sector (Ministry of Finance, 2018). For cocoa, MoFA provides technical support and the cocoa board oversees all operational issues (Ministry of Finance, 2018).

The Ministry of Lands and Natural Resources (MLNR) is in charge of the forestry and logging sector (Ministry of Finance, 2018). Other ministries such as Roads and Highways; Environment, Science, Technology and Innovation; Health; and Trade & Industry also undertake related activities that support agricultural development in the country (MOFA, 2015). The interconnectivity of various ministries suggests that the sector needs effective and holistic coordination of all the ministries for effective operations.

Performance of Agricultural Sector in Ghana: The Agricultural Sector growth rates for the years 2010 to 2017, was projected at 6.0% (MoFAa, 2017). According to the 2017 progress report of MoFA and the 2018 budget statement by the Ministry of Finance, between 2010 and 2016, the average growth rates for the agricultural sector was 3.5%. The lowest growth rate of 0.8% was recorded in 2011 and 5.7% in 2013. The low growth rate in 2011 was attributed to the poor performance of the fisheries (-8.7%) and forestry/logging (-14%) coupled with poor rainfall patterns. The sector's performance, however, experienced significant improvement in 2017. The agricultural Gross Domestic Product (GDP) in 2017 was 8.4%, exceeding the 2016 growth rate by 5.4 percentage points. The crops sub-sector was the highest with an average growth rate of 9.4% in 2017 (Ministry of Finance, 2018; MoFA, 2017).

The introduction of government flagship programme *"Planting for Food and Jobs* (PFJ)" which provides farmers with subsidized fertilizer, high yielding seeds and extension services contributed to improvement in the agricultural performance in 2017 as presented in Figure 2.2.

The inconsistencies in the sector's performance over the years as shown in figure 2.2 call for strategies that will attract consistent public and private investment due to its critical role in ensuring food security, poverty reduction and socio-economic development of the country.

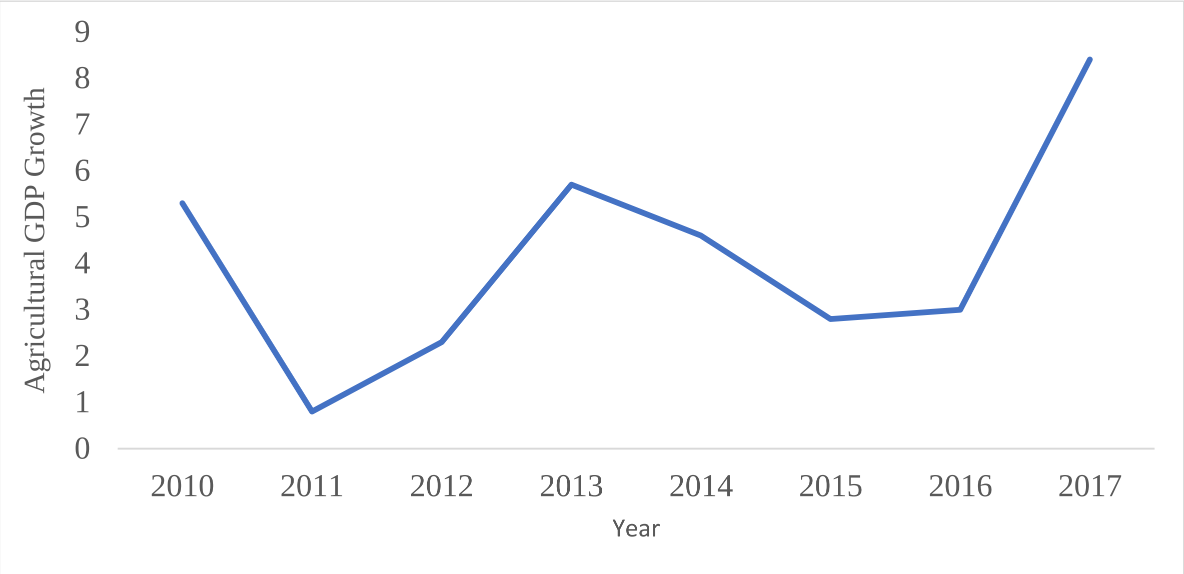

Figure 2.2: Real Annual GDP Growth Rate of the Agricultural Sector 2010 – 2017
Sources Ghana Statistical Service (2018)

2.3.2 Food and Agricultural Policies in Ghana

The Food and Agriculture Sector Development Policy (FASDEP I & II) is the main government policy document governing the activities of MoFA and other related ministries in Ghana. The FASDEP I was formulated in 2002 as a holistic policy document targeting the private sector as the engine of growth (MoFA, 2007). The FASDEP I was formulated in line with the Accelerated Agricultural Growth and Development Strategy (AAGDS) and agricultural modernization agenda of the government. After four years of implementation of FASDEP I, Poverty and Social Impact Analysis (PSIA) was conducted and concluded that FASDEP I cannot achieve its objectives due to the following reasons:

- Lack of proper targeting of the poor for the modernization agenda.

- Weak analysis of needs and priorities of the poor leading to wrong agenda setting.
- No clear road map for the Ministry of Food and Agriculture to execute agricultural interventions that were outside the domain Ministry of Food and Agriculture (MoFA, 2007)

Based on lessons learned from FASDEP I and upon broader consultation of stakeholders, the FASDEP II was formulated targeting fewer commodities and supporting all categories of farmers. It was also aimed to enhance the productivity of the agricultural commodity value chain by applying science and technology in production (MoFA, 2015). Six areas were identified as relevant for intervention under FASDEP II (MoFA, 2007).

They are "Food Security and Emergency Preparedness; Improved Growth in Income; Increased Competitiveness and Enhanced Integration into Domestic and International Markets; Sustainable Management of Land and Environment; Science and Technology Applied in Food Production and Enhanced Institutional Coordination" (Boateng & Nyaaba, 2014; MoFA, 2007).

Apart from the various areas targeted under the FASDEP II objectives, there were also specific policies and strategies for the various sub-sectors. These include "crop development policy, fisheries development policy, livestock development policy, and cocoa development policy". Strategies developed for service delivery were "irrigation development strategy, extension services delivery strategy, agricultural mechanization strategy, plant protection strategy, financial services delivery strategies, inputs distribution strategy, gender mainstreaming strategy, youth in agriculture and human resource development strategy"(MoFA, 2007)

According to MoFA (2007) inadequate allocation of funding, low prioritisation of food and agriculture sector by District Assemblies, inadequate response of other Ministries, Departments and Agencies (MDAs) to agriculture sector policy initiatives, inadequate response of private sector to policy initiatives and inadequate response of producers to policy initiatives were the risk identified as constraint to the success of FASDEP II. Other risk areas identified were adverse dynamics in international trade regimes for agricultural commodities, down-turns in world prices of key agricultural export commodities, poor rainfall patterns, an outbreak of pests and diseases and low commodity prices on the domestic market.

Foreseeing these risks and lack of mitigation strategy in the FASDEP II was a serious omission that might have affected the achievement of FASDEP II objectives. Low interest in private sector participation in agriculture and financial institutions engaging SHF was identified as a major setback to the success of FASDEP II (Awunyo-Victor & Al-hassan, 2014; Mustapha *et al.*, 2016).

In conclusion, the FASDEP II objectives appear to contain broader range of issues in the various sectors that requires attention. The most importance issue identified by FASDEP II was the identification and targeting specific commodities with their potentials for investment. However, the challenge that limited the success of FASDEP II has to do with limited funding for investment areas identified, poor implementation of projects, low interest of key stakeholders, low technology uptake by the targeted farmers and poor institutional coordination were identified by literature as barriers to the success of FASDEP II (Abdul-Razak & Kruse, 2017; Fearon & Adraki, 2015)

2.3.3 Medium Term Agricultural Sector Investment Plans in Ghana

To operationalise the FASDEP II, the METASIP I & II were developed as investment plans for the medium term (MoFA, 2018). The METASIP I was designed for the period of 2011 to 2015 with the aim of stimulating private sector investment in the medium-term

(Boateng & Nyaaba, 2014). The aim was also to increase agriculture growth by at least 6% annually with government increasing national budget allocation of at least 10% within the investment period (MoFA, 2015). METASIP II was formulated to replace METASIP I for the period of 2014 to 2018 aiming at modernising agriculture.

The investment under the METASIP I & II were largely executed as independent projects and treated as part of a range of projects. Even though the programme areas were designed as compliments, the interventions failed to meet the design requirements (MoFA, 2018).

2.4 Ghana Government Agricultural Flagship Programmes

Modernising the activities of SHF is government's policy priority (MoFA, 2015, 2018). Before 2017, notable flagship programmes seeking to modernise SHF activities and improve their productivity were the Ghana Commercial Agricultural Project (GCAP); Multinational NERICA Rice Dissemination Project; Agricultural Mechanization Centres, Youth in Agriculture with Block Farming concept, National Food Buffer Stock Company, the Fertilizer and Seed Subsidy Programme (Diao *et al.*,, 2014; Fearon & Adraki, 2015; Safo, 2016; Samrat, 2013; Udimal *et al.*, 2017; World Bank, 2012)

As part of campaign to remove the bottlenecks stifling the growth of the private sector and to provide enabling environment for growth, job creation, and prosperity for all, the New Patriotic Party in their 2016 Manifesto outlined flagship programmes for agricultural transformation in Ghana (New Patriotic Party (NPP), 2016)

These programmes include: "Planting for Food and Jobs, One District One Warehouse (1D1W), One District One Factory (1D1F), One Village One Dam (1V1D), Planting for Export and Rural Development (PERD) and Rearing for Food and Jobs" (Akoto, 2019; Ministry of Finance, 2018; New Patrotic Party (NPP), 2016).

The PFJ which was launched in April 2017 appears to be the government's main agricultural modernization programme targeting SHF (MoFA, 2017b). The PFJ campaign is anchored on five pillars: Provision of improved seeds, the supply of fertilizers, provision of dedicated extension services, marketing and e-Agriculture (MoFA, 2017b). According to the 2017 monitoring report of MoFA, the implementation of PFJ in 2017 led to an increased in crop yields, improved extension services and creation of jobs (MoFA, 2017a).

The 1D1W aim was to provide storage facilities to help address high postharvest losses that may be associate with expected bumper harvest due to the implementation of the PFJ. The 1D1F programme aimed was to establish at least, one factory in each of the 216 districts in Ghana to create economic growth, create jobs and transform the economic structure from raw material export to private sector value-added industrialized economy (Ministry of Finance, 2018).

The 1V1D targeted northern Ghana, part of Volta region and the northern part of Brong Ahafo region where dams are expected to be dug in every village to conserve water for domestic and agricultural activities" (New Patriotic Party (NPP), 2016)

The PERD was a decentralised tree crop project to develop nine tree value chains in the various districts. The trees under consideration were: Cashew, Citrus, Coffee, Cotton, Coconut, Mango, Rubber, Oil Palm and Shea nut trees. The aim of PERD was expected to provide raw materials to feed the IDIF that was to be established. It was also to promote rural economic growth and improve household incomes of rural farmers through the provision of certified improved seedlings, extension services, business support and regulatory mechanisms (Farmer Helpline, 2018)

whiles these bold steps by the government was necessary, there is no proper documentation of detail implementation plan, funding sources, actual implementation commencement and exit plan. Information of the role of OGS on SHF productivity will be relevant to guide government implementation of its flagship programmes due to its private led modernization concept.

2.5 Concept of Smallholder Farmers

The conceptualization of smallholder farmers (SHF) varies across countries and context. While the SDGs Monitoring Framework refers to it as "food producers", other literature calls it small farmers, family farms, peasant farmers or subsistence farmers (Dittoh & Akuriba, 2018; Garner & de la O Campos, 2014; Khalil *et al.,* 2017; MoFA, 2007, 2017b; Murphy, 2012)

Dixon *et al*. (2004) summarises SHF when they say "smallholder farmers refers to limited resource endowment of farmers compared to those of other farmers in the sector". In the same vein, World Bank, (2003) explained the concept of smallholders as "those farms with low asset base and operating in less than 2 hectares of land". For Brooks *et al.,* (2009), smallholders are "farm households which struggle to be competitive, either because of their endowments of assets compare unfavourably with those of more efficient producers or because they have to content with under-developed markets". Similarly, in Murphy (2012), smallholder farmers are "characterized by marginalization in terms of their access to credit, information technology and capital". The Ministry of Food and Agriculture in Ghana (2016) maintains that, a farmer is SHF based on their level of resource endowment and landholdings of less than two (2) hectares.

This study is much associated with the concept presented in the report of High-Level Panel of Experts on Food Security and Nutrition (HLPE) in 2019. According to the HLPE 2019 report, " smallholders are agricultural holding run by a family using mostly (or only) their own labour and deriving from that work a large but variable share of its income, in kind or in cash. The family relies on its agricultural activities for at least part of the food consumed, be it through self-provision, non-monetary exchanges or market exchanges. The family members also engage in activities other than farming, locally or through migration. The holding relies on family labour with limited reliance on temporary hired labour, but may be engaged in labour exchanges within the neighbourhood or a wider kinship framework".

As stated by Narayanan (2002), one of the reasons why the sole consensus around the concept of SHF may lack an agreed definition is the wide variety of farm structures and characteristics across different contexts and geographical locations. Much literature mentions the absence of such agreement, but few papers venture proposing acceptable definition.

In the policy debate, the notion of "smallholder farmers" goes hand in hand with the idea of disadvantage, risk of poverty, lack of opportunities, and need of support. Hence an ideal definition should be consistent with the concepts of absolute poverty, severe food insecurity and access of optimal-productive resources and must be based on a criterion that does not necessarily depends on outcomes that have to be measured.

Following the various debates Brooks *et al.* (2009); Garner & de la O Campos (2014); HLPE (2019); Khalil *et al.* (2017); Murphy (2012); Narayanan (2002) and World Bank (2003), this study summarises the definition of SHF as the one who is disadvantaged in access to optimal productive resources, lack of market access, marginalized in policy space, food insecure, absolute poverty and dependent on less than five (5) hectares of land for farming activities. Sorghum SHF are therefore defined as sorghum farmers who are dependent on not more than five hectares of land for cultivating sorghum and other crops, are disadvantaged in access to optimal productive resources, lack of market access, food insecure, absolute poverty and are marginalized in the policy space.

2.5.1 Smallholder Farmers Crop Productivity and Profitability

The term productivity has largely been used to express different meanings and has provoked many conflicting interpretations. It is sometimes regarded as the overall efficiency with which a production system works, while on other occasions, it is defined as a ratio of output to the application of a given resource (Darku *et al.*, 2016; Dharmasiri, 2012).

Profitability, on the other hand, is the difference between the cost of production and yield per production area, usually, measured by kilograms per acre or per hectare (Devkota *et al.*, 2019; Montgomery *et al.*, 2017; Wünsch, Gruber *et al.*, 2012). The main variable differentiating profitability and productivity is cost of production and price. While a farmer may obtain higher productivity, when the cost of production is high and selling price is low, that farmer is likely to make losses. On the other hand, lower productivity, low cost of production and higher prices can lead to higher profitability (Devkota *et al.,* 2019; Montgomery *et al.,* 2017; Wünsch *et al.,* 2012). The table 2.1 shows average and actual productivity in Ghana for major crops for the 2016 farming season.

Table 2.1: Productivity of Major Staple Crops in Ghana

Staple crops	Achievable yield	Actual yield	% Achieved
Maize	5.50	2.05	37.27
Rice (Paddy)	6.00	3.01	50.17
Cassava	45.00	20.68	45.96
Yam	52	16.74	32.19
Sorghum	2.00	1.24	62.00
Soybeans	3.00	1.70	56.67

Source: MoFA (2017)

In Ghana, SHF productivity and profitability is a reflection of the condition under which they operate. Most farm holdings of SHF are less than 5 hectares per household and dependent on traditional production technologies. There abounds considerable evidence of productivity gaps of SHF in Ghana (Villano *et al.,* 2019). Table 2.1 contain 2017 national productivity of major staple crops in Ghana. Smallholder farmers face numerous challenges in production, ranging from limited or lack of access to technical assistance, modern inputs, access to credit, and mechanization services (Al-Hassan *et al.,* 2013; Baiyegunhi *et al.,* 2019; Donkor & Owusu, 2019; Feleke *et al.,* 2017). These constraints led to their actual yields falling below their potential yields leading to low incomes and food insecurity. The efforts to address the yield gaps should be relentless if the contry can make significant in her support to achieving the SDG's, especially, goals one and two.

The table 2.2 contains trend of productivity in metric tonnes per hectare from 2013 to 2017. There was increase in productivity of some staple crops but the increment is still below the achievable yields for almost all the crops. The achievable yields for sorghum for instance was 2 tonnes per hectare (table 2.1), but the highest yield ever achieved was 1.24 in 2017 implying opportunity for sorghum farmers to make more income through the adoption of yield improvement programmes.

Table 2.2: Trends of Productivity in Crops (MT/Ha) in Ghana

Crop	2013	2014	2015	2016	2017*	% Change
Maize	1.72	1.73	1.92	1.99	2.05	3.0
Rice (Paddy)	2.64	2.69	2.75	2.92	3.01	3.1
Millet	0.97	0.96	0.97	1.16	1.05	-9.5
Sorghum	1.14	1.14	1.00	1.14	1.24	8.8
Cassava	18.27	18.59	18.78	20.25	20.68	2.1
Yam	16.78	16.63	16.96	17.42	16.74	-3.9
Cocoyam	6.50	6.48	6.49	6.53	6.79	4.0
Plantain	10.81	10.74	10.90	11.17	11.77	5.4
Groundnuts	1.24	1.28	1.24	1.30	1.37	5.4
Cowpea	1.24	1.21	1.25	1.41	1.37	-2.8
Soyabean	1.64	1.63	1.65	1.65	1.68	1.8

Source: MoFA (2017)

2.5.2 Postharvest Loss Among Smallholder Farmers

Postharvest loss (PHL) is defined as a measurable decrease in the edible part of the food available for consumption but never made it to the consumer’s table (Chegere, 2018; Kiaya, 2014) Postharvest loss concerns have received global attention due to its effects on food security and the environment. The Food and Agricultural Organisation of The United Nations put the value of PHL in SSA as 4 billion USD a year (Sheahan & Barrett, 2017). This figure exceeds the total food aid received in SSA over the last decade. For the World Bank (2011), crop production constitutes about 70 percent of incomes in SSA of which 10 to 20 percent crops are loss through post-harvest. The annual value of the losses is estimated at USD 4 billion which is equivalent to calorific requirement of 48 million people annually in SSA (Wold Bank, 2011)

Reducing PHL does not only improve SHF profitability, but also contribute to reduction in climate change, help stabilize the import bill due to limited resources invested in importation of food and improve labour productivity due to healthy living as a result of consuming less poisonous food (Affognon *et al.,* 2015; Goldsmith *et al.,* 2015; Rembold *et al.*, 2014)

Causes of PHL in developing countries is attributed to poor postharvest infrastructure, limited access and application of improved technology in food production and harvesting, high illiteracy among farmers to follow appropriate harvest and postharvest management practices, poor extension services and unfriendly weather conditions (Affognon *et al.*, 2015; Chegere, 2018; Sheahan & Barrett, 2016; Wold Bank, 2011)

In Ghana, most SHF depends on outmoded harvesting methods, stored their harvested produce in unhygienic conditions after harvest exposing them to pest, unfriendly weather leading to high PHL (Affognon *et al*., 2015). Postharvest loss and its implication to food security have received global attention but investment in PHL reduction in Ghana is still very low (Ministry of Finance, 2018). Some selected initiatives in Ghana to address PHL include the Warehouse Receipt System, Ghana Commodity Exchange program; One District, One Warehouse and establishment of National Food Buffer Stock Company (Ministry of Finance, 2018; MoFA, 2017b, 2018). Coulter & Onumah (2002) articulated the importance of regulated warehouse receipt system in addressing marketing challenges and emphasised the need to encourage stakeholder participation for effective implementation.

Another major challenge to the PHL campaign is lack of comprehensive data on PHL loss for various crops. Limited knowledge in measuring PHL has led to oversimplification or overestimation of loss figures on most occasions. Sometimes estimates of a single national figure for a year are constantly being quoted for several years (MoFA, 2016). FASDEP II estimated PHL in 2007 as 20%-50% for fruits, vegetables, roots and tubers, and 20%-30% for cereals and legumes (MoFA, 2007). These figures are constantly being quoted and have now become an accepted figure for PHL in Ghana. The approach may be misleading since PHL in a given crop varies from other crops and varies across seasons (MoFA, 2016). At the 2018 biannual review meeting held in Gabon Brazzaville to assess Africa countries' progress towards achieving CAADP commitments, PHL was not among the indicators for Ghana due to lack of data (Kiaya, 2018). Uncertainty in estimating PHL and lack of reliable data of specific PHL loss in a given crop in Ghana could lead to poor policies to address losses and also, sub-optimal choices of strategies to reduce the losses.

Various literature attempted to estimate the postharvest loss in cereals, specifically, in sorghum. They suggested seven stages where losses normally occur (Kiaya, 2018; Kitinoja & Kader, 2015; Sheahan & Barrett, 2016). These are a pre-harvest stage, harvesting, and initial handling, gathering and heaping, transportation/ carting, winnowing/threshing, drying, and storage.

Pre-harvest sorghum loss occurs when there is damage to the grain in the field before harvesting. This could be due to biological and biotic factors such as poor control of weeds, insects, pests and diseases (FAO, 2011). Most SHF pre-harvest practices are poor due to limited investment, limited extension services and high level of illiteracy among SHF to follow good farming practices (MoFA, 2017).

Harvesting and initial handling factors: Sorghum harvesting and handling are done manually by most SHF. During the harvesting stage, losses are mainly due to shattering and shedding of grains with the amount of loss largely dependent upon the duration of harvesting (FAO, 2014b). Over maturity and delayed harvesting is reported to be a major factor contributing to postharvest loss at harvesting stage (Huang *et al.*, 2017; Jones *et al.*, 2018). In Ghana, farmers leave harvested grains on the field to dry because they lack drying facilities (MoFA, 2017a).

Gathering and Heaping: Gathering and heaping of sorghum is usually done by women and children (MOFA, 2016). After harvesting, the sorghum grain heads are gathered and heaped on the farm to either be transported to the farmhouse or to be threshed. Within the heaped period, substantial proportion of grains are either damaged, loss or contaminated. This is due to rainfall, high moisture content or pest infestation (Akuriba & Asuming-Brempong, 2012).

Drying: Normally, grains are dried on bare grounds before carting for threshing (Kitinoja & Kader, 2015). Farmers who primarily depend on this method of drying are faced with challenges in the raining season. Also, the tendency of pests and rodents to attack during this period is high (Hengsdijk, 2017). Grains dried on bare floor could be contaminated with foreign materials, dirt, rainfall, pests, insects, livestock and bird attack (Kiaya, 2018). The solar driers are recommended for grains but highly expensive for SHF to afford.

Threshing and winnowing: Threshing of sorghum is still a major challenge. Most SHF depends on manual threshing using sticks to separate grains from the thresh (MoFA, 2017). This process leads to losses due to splashing or incomplete threshing. When the harvest is threshed before it is fully dried, some grains will remain in the stalks and if the grain is threshed when is damp and immediately stored, it will be much more susceptible to micro-organisms and aflatoxin contamination (Africa Union, 2018). Limited availability of threshers for sorghum is a major cause of sorghum postharvest loss.

Storage: Storage is an important activity in the postharvest chain as it allows farmers to keep their grains for good prices and for future consumption (Gitonga *et al*., 2013; Hengsdijk, 2017). Good quality grains can only be realized if the storage conditions are appropriate. Improper storage can cause stored sorghum to be contaminated by aflatoxin and also, pest and rodent infestation (Affognon *et al.*, 2015; HLPE, 2014; Neme & Mohammed, 2017). Storage losses in Ghana are on-farm, household-level storage or market storage. According to FAO (2014), on-farm storage losses are between 4-10 while market storage is between 1-2%. For Rembold *et al.* (2014), on-farm storage is between

2-5% and 2-4% on market storage for grains. Limited warehouses compelled SHF to either store their sorghum on the farms or in their rooms leading to pest infestation leading to grain losses (Rembold *et al.,* 2014). As part of the government's agricultural flagship projects, warehouses are being constructed to help reduce storage losses.

Transportation/carting: Transporting sorghum is another herculean task as in Ghana and many parts of Africa, women and children have to convey farm produce on their heads and shoulders to the nearest farmhouses (Africa Union, 2018). According to FAO (2014), grains losses due to poor transportation is between 1-2%. Produce are usually conveyed by women using head pans, baskets and on few occasions, animal tracking such as bullocks and donkey carts are commonly used (MoFA, 2007). Some farmers also engaged the services of motor tricycle popularly called "*motor- king*" for a fee. Farm produce are normally transported between the farmer's fields to where grains are threshed and the threshing floor to the storage centre and to the markets. Transportation could be made easier with motor trucks or cars but this is dependent on the availability of access roads and farmers' ability and willingness to pay for the transport cost (Hell & Mutegi, 2011). The degree of grain loss during transportation is mostly proportional to the distance from the farm to the final destination (Rembold *et al.*, 2014).

2.5.3 Smallholder Farmers and Climate Change

Climate change and its impact on the environment and socio-economic activities of communities is a major concern for policy makers in SSA (Abdul-Razak & Kruse, 2017; Pandey *et al.,* 2017; Thompson, Berrang-Ford, & Ford, 2010) . According to (Porter *et al.* (2014), climate change in the last 30 years has contributed to a declining agricultural performance between 1% to 5% per decade. The world poorest are said to suffer more from the impact due to their weak capacity to adapt (Adeyeri *et al.*, 2019).

Climate change data in Ghana from 1961 to 2000 shows a progressive increase in temperature and declined to mean annual rainfall pattern in all the six agro-ecological zones (UNEP & UNDP, 2013). The annual average temperature has increased by 1°C in the last 30 years. (UNEP & UNDP (2013) projected temperature to continue to rise, while rainfall is predicted to decline in all agro-ecological zones in Ghana (Table 2.3 and Table 2.4)

Table 2.3: Mean Annual Change in Rainfall (%) in Ghana

Year	Sudan	Guinea	Transitional	Deciduous	Rainforest	Coastal
2020	-1.1	-1.9	-2.2	-2.8	-3.1	-3.1
20150	-6.7	-7.8	-8.8	-10.9	-12.1	-12.3
2080	-12.8	-12.8	-14.6	-18.6	-201.2	-20.5

Source: Minia *et al.* (2004)

Table 2.4: Projected Mean Annual Temperature Changes in Ghana

Year	Sudan	Guinea	Transitional	Deciduous	Rainfores	Coastal
2020	0.8	0.8	0.8	0.8	0.8	0.8
20150	2.6	2.5	2.5	2.5	2.5	2.5
2080	5.8	5.4	5.4	5.4	5.4	5.4

Source: Minia *et al.* (2004)

The climate change situation is more serious in northern Ghana which has increasing number of droughts, floods and bushfires. The SHF with minimal livelihoods alternatives are largely affected by the impact (Aniah *et al.,* 2019; Dickinson *et al.,* 2017; Etwire *et al.,* 2013). Majority of SHF in northern Ghana rely on rainfed for their agricultural activities and any variations in the rainfall pattern translate to low farm productivity, lower-income and high vulnerability (Morton, 2013; Yaro, 2013). According to Abdul-Razak & Kruse (2017), since patterns and volumes of rainfall determines agricultural productivity in northern Ghana, people whose livelihoods depends on agriculture would be largely affected. According to Antwi-Agyei *et al*. (2018), crop yields are estimated to reduce in Ghana by 7% by 2020 as a result of the projected decline in rainfall which would negatively affect SHF more since their main economic activity is farming.

It is important to acknowledge the efforts of researches seeking remedy to address the impact of climate change on vulnerable communities. Most of the studies centred on farm-level resilience and adaptation strategies (Adu *et al.,* 2018; Dzanku, 2015; Etwire *et al*., 2013; Yaro, 2013). Limited studies examined specific interventions that increases incomes of SHF and indirectly empowers them to become less vulnerable. Knowing the level of vulnerability among various groups of farmers and the impact of a specific agricultural intervention that has demonstrated positive impact on livelihoods would be an ideal step for policymakers. Information on SOGS and its effect on SHF farmers' profitability and subsequently, their vulnerability is relevant.

2.5.4 Smallholder Farmers Vulnerability to Climate Change

There are different definitions of climate change vulnerability. The most comprehensive definition commonly applied in literature is the one by IPCC 2009 authored by Hahn Riederer and Foster (2009). Hahn *et al*. (2009) defines climate change as "the degree in which a system is susceptible and unable to cope with adverse effects of climate change while vulnerability is a function of magnitude and rate of which a system is sensitive, exposed and adapt to changes in climate" (Hahn, Riederer, & Foster, 2009).

Vulnerability is usually considered a function of three elements. "sensitivity to hazard, exposure to hazard and the capacity of that system to adapt to the hazard as a result of the climate change"(Adu *et al*., 2018; Chinwendu *et al.,* 2017; Hahn *et al*., 2009; Jamshidi *et al*., 2019). Chinwendu *et al*. (2017) have argued that vulnerability explains the degree of risk and inability of a system to resist to the climate variations. The exposure is the degree to which a system is exposed to the effect of changes in climate and sensitivity is the extent to which a system is impacted adversely or positively by climate change.

Smallholder farmers in Ghana face a wide range of climate-related risks ranging from weather failure, total crop failure, market risk, postharvest loss with negative effects on livelihoods (Jamshidi *et al.*, 2019; Lahouar *et al.*, 2016; Makate *et al.,* 2019). How to withstand this climate shocks has been the concern of many researchers. Most studies focus on identifying adaptation and coping strategies by SHF to reduce the adverse impacts on their livelihoods (Antwi-Agyei, Dougill *et al.*, 2018; Boansi *et al.*, 2017). Other studies such (Abdul-Razak & Kruse, 2017; Etwire *et al.,* 2013; Yaro, 2013) have explored strategies that local institutions adopt to promote climate change adaptation in northern Ghana. Some studies also focused on the role of indigenous knowledge in farming to address the adverse effect of climate change on livelihoods (Bhattacharjee & Behera, 2018; Pandey *et al.,* 2017)

There exist limited studies exploring interventions that link farmers and business entities such as agribusiness companies who support farmers to improve their productivity and profitability and how such interventions could empower farmers to indirectly become less vulnerability to climate change. It is against this backdrop that this study examines OGS to establish its appropriateness to deal with the diverse constraints inhibiting the performance of SHF and enhance their livelihood outcome. The possibility of SHF attaining higher income through out-grower schemes and by inference, improved livelihoods is reported by Minot (2015); Maertens & Velde (2017) and Ragasa *et al*. (2018).

2.6 Outgrower Scheme Debate

In the era of globalization and market liberalization, there are globally concerns of the role of SHF in the market economy due to their subsistence nature (Almas & Obembeb, 2014; Koira *et al.,* 2014; Gaffney *et al.,* 2019). Smallholder farmers could be marginalised as the agribusiness companies may capitalise on the market opportunities to take over their lands (Eaton & Shepherd, 2001). This could lead to farmers abandoning farming activities for alternative livelihoods which has been the case in most developing countries (Bellemare & Bloem, 2018; Jayne *et al.*, 2016). Attempts by policy makers to avert the situation is by providing rural communities with social support services such as subsidising farm inputs (FAO, 2014a; Saghir & Hoogeveen, 2017). Several impact assessments reports proved that government interventions in Ghana has minimal impact on the beneficiaries (Fearon & Adraki, 2015; ISSER, 2012).

Following Maertens & Velde (2017) and Fawad et al. (2019), OGS is recommended as appropriate in dealing with these challenges. The OGS provides linkages and offers important pathway for SHF to obtain improved agronomic services and inputs and also, approach their farming with business mindset. These services and support systems apart from demographic characteristic of the farmers such as gender and age, are said to be the main motivations for SHF participation in OGS and also, modernising their farming activities (Gebrezgabher *et al.*, 2015; Ghimire *et al.*, 2015; Gover, 1990; Mariano *et al.,* 2012; Udimal *et al.,* 2017). Recent report by Ragasa, Lambrecht, & Kufoalor (2018) and Fawad *et al*. (2019) supported the earlier reports on benefits of OGS to SHF claimed that, the OGS also creates opportunities for farmers to access market and industries to obtain their raw materials from farmers.

The OGS is defined as a business transaction between farmers and buyers for the purposes of production and supply of agricultural commodities based on formal or informal prior agreement (Minot & Nicholas, 1986; Eaton & Shepherd, 2001). Minot (2011) defined OGS as an existing ad hoc trade arrangement being replaced with well-structured commercial trade arrangement between farmers and traders leading to a vertical integration in a given agricultural value chain. Food and Agricultural Organisations of the United Nation in 2012 integrates the above definitional schisms to define OGS as supply agreements between agribusiness companies and farmers leading to mutual gains (Paglietti & Sabrie Roble, 2012)

The OGS and contract farming are often used interchangeably in literature (Bellemare, 2012; Bellemare & Bloem, 2018; Ragasa *et al.,* 2018; Wendimu *et al.,* 2016).

There are however some subtle differences between the two schemes depending on how the arrangement is made and who initiates and controls the scheme. According to Glover & Kusterer, (1990), contract farming is a private-led scheme whiles OGS are public led enterprises. This distinction appears to be losing relevance in recent times as private companies also engaged outgrowers on contractual bases other than the usual contract farming (Barrett *et al.*, 2012; Maertens & Velde, 2017; Ton *et al.,* 2017). This study found no differences between OGS and contract farming.

The importance of OGS and its impact on participating farmers is viewed from different lenses. Among the proponents views, adoption of OGS has the potential to transform SHF subsistence farming to commercial oriented enterprise (Maertens & Velde, 2017; Minot, 2015; Minot & Ronchi, 2014; Paglietti & Sabrie Roble, 2012; Ton *et al.,* 2015). They argued that OGS support farmers with new agronomic information, improved inputs, credit and guaranteed market on contractual bases. The conditions attached to these services compelled subsistence farmers to change their practices in fulfilment of the contractual obligations.

Risk sharing argument was advanced by Glover & Kusterer (1990) that, OGS is a way of sharing production risk between farmers and buyers. According to them, the SHF on their own tend to be risk averse and are unlikely to invest in expanding production for uncertain market. Against this uncertainty, agribusiness companies linked capital to the farmers via contracts with guaranteed markets. Similar to Glover & Kusterer (1990) assession, Eaton & Shepherd (2001); Barrett *et al.* (2012) and Ton *et al. (*2017) also concede that, OGS linked SHF to guaranteed markets and create opportunity for them to participate in high-value markets.
From the international trade point of view, Paglietti & Sabrie Roble (2012); Barrett *et al. (*2012); and Odunze et al. (2015) claimed OGS are encouraged by multinational donor agencies and governments as a channel that links SHF to global markets and at the same time, connecting them to yields improving technology. The literature refers to this kind of investment as *responsible investment*. Some recent studies confirming earlier studies on relevance of OGS concluded that, the OGS helped SHF overcome market imperfections, reduce market risk and reduce their vulnerability to climate shocks (Johanna et al., 2019; Rhebergen *et al.*, 2018).

Despite optimism expressed by various authors on the positive outcomes of OGS, others have contrary views on welfare gains by SHF for participating in the OGS (Adams *et al.*, 2019; Fawad *et al.*, 2019; Huang *et al.*, 2018; Manda *et al.*, 2018; Narayanan, 2014; Odunze *et al.*, 2015; Oya, 2012; Vicol, 2017). According to Narayanan (2014), participation in OGS shows high level of dissatisfaction among farmers in southern India and high exit rate due to high debt they incurred. For Odunze *et al.* (2015) and Vicol (2017), power imbalance between SHF and buyers could subject the farmers to farm labourers. Vicol (2017) remarked that "In India, the politics of land and agriculture means that land acquisition is not a viable option for foreign or domestic agri-business capital searching for investment and accumulation opportunities. Agri-business is instead coming to control rural land through other means such as CF, while continuing to introduce new modes of production and accumulation into already highly unequal rural livelihood landscapes. Contract farming entangles farmers in new relationships of capital, debt and power that often do not result in the pro-poor rural development outcomes imagined by some".

Ragasa *et al*. (2018) study on maize OGS in Upper West Region of Ghana claimed the OGS has potentials to increase productivity and improve supply of high-quality maize to buyers, but farmers on the scheme were making low profit than non-scheme members due to high cost of production such as high input cost. The report claimed that the yield increase by participating farmers was not enough to offset the high cost of inputs provided by buyers.

On gender perspective, Adams *et al.* (2019) study on gender balance and sugarcane outgrower scheme in Zimbabwe argued that, while the scheme gave bargaining power for participating women, it has created gender gap in land control, heightened demand for women's farm labour and gave them limited leeway to demand appropriation of their unpaid labour from their husbands.

The third set of researchers have neutral stands on impact of OGS and concluded that, it should be analysed base on context and content specific (Bellemare & Bloem, 2018; Fawad *et al.*, 2019). They argued that, benefits of OGS is based on the type of contractual agreement between producers and buyers. In occasions where OGS failed, reports of poor communication among parties, unfavourable terms and dictating of prices by services providers were reported.

2.6.1 Types of Outgrower Schemes

While some OGS are structured around formal contracts and may include provision of credit and inputs, other schemes are structured around informal contracts without credit, supply of inputs or provision of extension services (Eaton & Shepherd, 2001; Hobden & Sands, 2017; Paglietti & Sabrie Roble, 2012) Five different types of OGS were categorized by Hobden & Sands (2017) which is in conformity with FAO earlier classification published by Eaton & Shepherd (2001). The various types of outgrower schemes listed are as follows:

Centralised Model of Outgrower Schemes: The centralized model is a form of vertical coordination of which buyers provide production and marketing services to SHF on their own land. Crop category in this model are those requiring high level processing such as coffee, cocoa and tea. The OGS operated by Blue Skies Company Limited in the Akwapim South Municipality of Ghana is a typical example of Centralised Outgrower Model (Agbelengor, 2015)

Nucleus Estate Model: Buyers often own a plantation or estate and at the same time engage SHF in the neighbourhood to produce. According to Eaton and Shepherd (2001), the nucleus-estate model is suitable for perennial crops such as oil palm, rubber and coffee. Example of nucleus estate model in Ghana is the Ghana Oil Palm Development Company Limited (GOPDC) scheme. Under the GOPDC arrangement, the company has a plantation estate and also supporting SHF with inputs and extension services for a reliable supply of fresh oil palm (Loggoh, 2013)

The Multipartite Estate Model: The multipartite estate model is a joint venture involving a public entity, a private firm and farmers. Baumann (2000) contend that most of the multipartite estate models are practiced in developing countries. Typical example is

Rubber Outgrower Plantation Project comprising the financial institutions, Ghana Rubber Estate Limited and the outgrowers (Paglietti and Sabrie, 2012).

The Intermediary Model: Under the intermediary model, firms do not contract directly with the farmers but does it through an intermediary. The firms subcontract intermediaries who deal directly with farmers. The intermediary could be farming committees or aggregators. The contracting firms have limited control over the farmers and how the produce is produced (Eaton & Shepherd, 2001) The current GGBL OGS mimic this model (Paglietti & Sabrie Roble, 2012; Sarfo-Mensah, 2017).

2.7 Summary and Knowledge Gap in the Literature

In summary, the review found the role of SHF in Ghana's agriculture development as crucial in poverty reduction, job creation and overall economic development. Their low productivity, high PHL, and low profitability is due to challenges ranging from difficulty in access to quality productive resources, knowledge gap, lack of market access and guaranteed prices and impact of climate change.

To address these challenges, FASDEP I and II were formulated with METASIP I and II as medium-term investment plans to modernise the activities of SHF. While investment as part of the modernization agenda to improve productivity was lauded by many stakeholders, limited investment in the area of postharvest loss reduction and market access were identified as serious drawback to SHF modernisation agenda.

The role of OGS in supporting SHF production and market access is recommended as having potentials to transform their subsistence farming practices to see farming as a business. Despite the optimism expressed on important role OGS play in transforming the subsistence farming activities of SHF, there is limited research on effect of OGS on SHF productivity, postharvest loss and profitability on indigenous crops such as sorghum in Ghana.

On the impact of climate change on the livelihoods of SHF, the literature found severe effect on socio-economic activities and livelihoods of rural communities. Policy recommendations to mitigate the effects by different studies were in the area of adaptation and coping mechanisms. There is limited research in the area of OGS and its relationship to climate change mitigation among SHF.

In conclusion, there is literature gap on the effect of OGS on smallholder sorghum farmer's productivity, their postharvest loss reduction, increasing their profitability and reducing their vulnerability to climate change of which this thesis is to investigate.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter is about the methods used to achieve the research objectives. It begins with a section explaining the conceptual, analytical and theoretical frameworks of the study. The chapter also elaborates on the data collection processes including sources of data, sampling methods, interviews conducted, analysis of the data and the study area. The final section of the chapter presents the scope and limitation of the study.

3.2 Conceptual Framework of the Study

Smallholder farmers face imperfect credit and input market (Aniah *et al.,* 2019; Ebata & Hernandez, 2017; Gaffney *et al.,* 2019). They lack extension services, they have difficulty accessing credit and agro-inputs, poor pricing and limited access to ready market (Al-hassan, 2014; Dittoh & Akuriba, 2018; Ecker, 2018; Baiyegunhi *et al.,* 2019). They are also confronted with negative impacts of climate change which are associated with low and erratic rainfall patterns, floods, droughts, pests and disease infestation (Abdul-Razak & Kruse, 2017; Makuvaro *et al.,* 2018). These issues negatively impact on their productivity, post-harvest management and increase their vulnerability to climate change. The combined effect is poor livelihoods (Aniah *et al.,* 2019).

In the context of climate change, vulnerability is conceptualised as fall in well-being leading to people's inability to cope with changes in climate variables (Shah *et al.,* 2013; Pandey *et al.,* 2017; Jamshidi *et al.,* 2019). Whiles there are interconnectivity between low income earning, asset holding and livelihoods empowerment (Dzanku, 2015; Pandey *et al., 2017),* vulnerability to climate change equally have replicate effect on livelihoods (Alobo, 2019; Aniah *et al.,* 2019). Low income earners and low asset holders are vulnerable to climate change than high income earners (Shah *et al.,* 2013). Vulnerability also weakened labour productivity and limit capacity of the affected person to obtain quality livelihood outcomes such as access to food, access to shelter and quality health care (Travis, 2014; Adu *et al.,* 2018). Any intervention that improves incomes will probably influence livelihoods and vulnerability to climate change (Yaro, 2013; Tshilidzi *et al.,* 2016; Pandey *et al.,* 2017).

According to Barrett *et al.* (2012), Abebe *et al.* (2013), Maertens & Velde (2017) and Bellemare & Bloem, (2018), participation in OGS is expected to improve farmers' productivity, reduce their postharvest losses and increase their profitability, increase their disposable income and increase their asset holding. Improved incomes and asset holding is an indication of ability to adapt to climate stress and become less vulnerable to climate change (Abdul-Razak & Kruse, 2017; Antwi *et al*., 2015; Boansi *et al*., 2017; Jamshidi *et al*., 2019)

In the conceptual framework in Figure 3.1, smallholder sorghum farmers are experiencing low productivity, high postharvest losses, difficulty accessing guaranteed market leading to low profitability. Their activities are further worsened by impact of climate change. On the other hand, there is demand for sorghum by agribusiness companies and manufacturing companies. The Agribusiness Companies therefore enter into contractual arrangement with the manufacturing and processing companies and agreed on some package to support the smallholder farmers to produce sorghum of certain quality, quantity and an agreed price. In addition, the manufacturing and processing companies engages financial institutions to support the Agribusiness Companies to extend their support to the smallholder farmers.

The agribusiness companies then engaged the smallholder farmers on contractual bases again, support them with inputs, credit and extension services to improve their productivity. They also engaged government and private Extension Officers to train the farmers on postharvest management leading to low postharvest losses. Enhanced productivity and low postharvest losses leads to improved profitability and increase disposable income. Due to guaranteed market and guaranteed supply, transaction cost of searching for market and price negotiation is also minimized for both producers and suppliers (Mwangi & Kariuki, 2015).

With the improved profitability, the SHF can diversifies their investments into off-farm activities and livestock production and thereby are able to withstand climate shocks and become less vulnerable to climate change. When farmers are less vulnerable to climate change, they are more likely to have improved livelihoods (Figure 3.1).

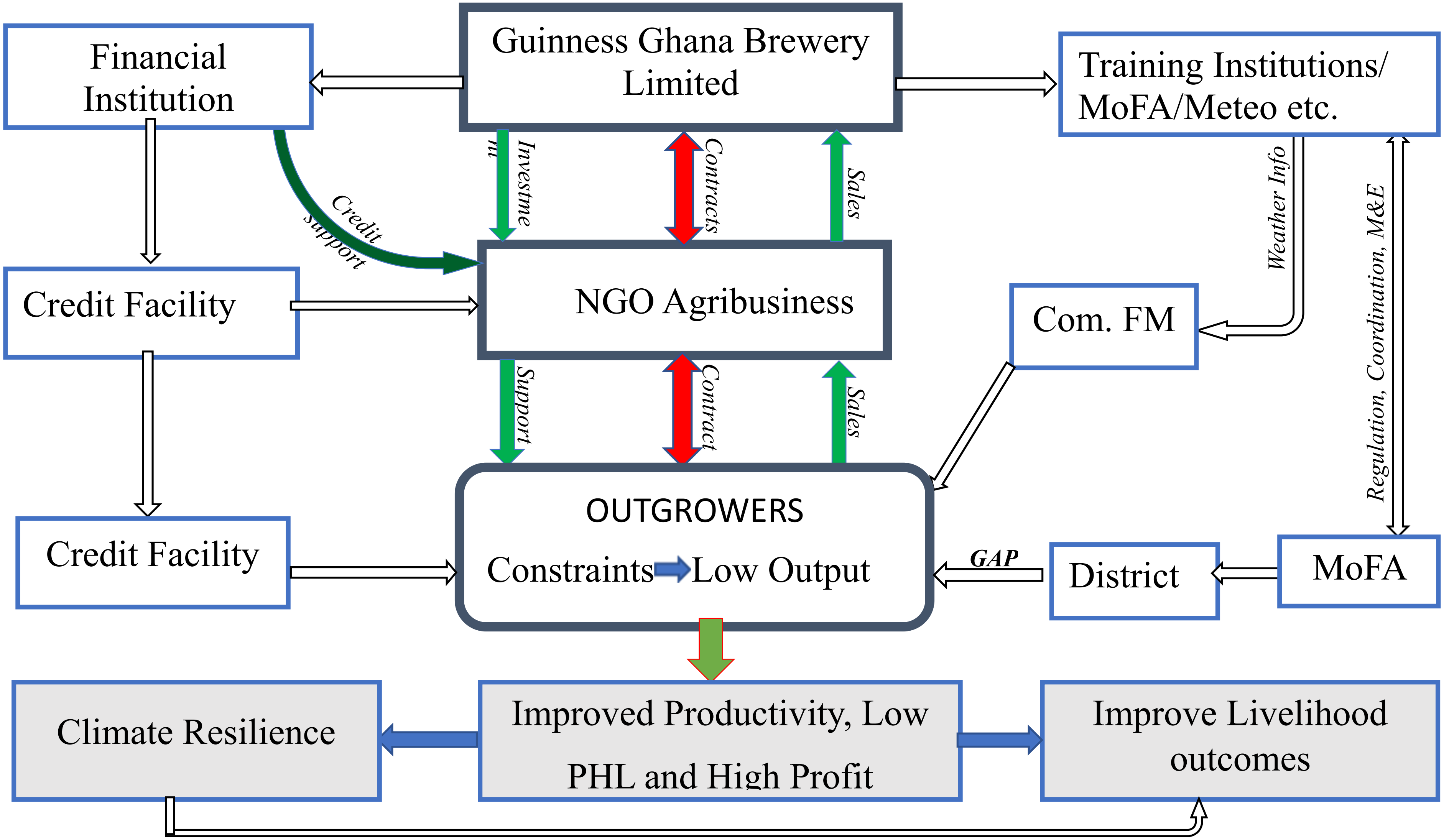

Figure 3.1: Conceptual Framework of Sorghum Outgrower Scheme in Ghana

Source: Author's conceptualization

3.3 Analytical Framework

The general analytical framework of the thesis is based on Sustainable Livelihood Framework (SLF) (DFID, 1999; Knutsson, 2006; Pandey *et al.*, 2017; Scoones, 1998). The concept of SLF was founded in 1990s by Robert Chambers and later developed by Chamber and Conway in the 1990s (Chambers & Conway, 1991). Sustainable livelihood is defined as “accumulation of both material and social assets by people for positive living” (Kemp *et al.*, 2009; Pandey *et al.*, 2017). Livelihood is said to be sustainable when “people can cope and recover from shocks, stresses and enhance their capabilities without undermining the importance of the natural resource base” (Shah *et al.*, 2013; Pandey *et al.*, 2017).

The sustainable livelihood concept views poverty as a multifaceted concept, encompassing different variables beyond just economic growth (Pandey *et al.*, 2017; Bhattacharjee & Behera, 2018). Other factors of relevance beyond economic variables include social network, empowerment and right of the poor to have meaningful living in all spheres of life. This is an important information to understand the need to involve the poor in livelihood empowerment activities such as the outgrower scheme activities. The SLF has been simplified with a model in Figure 3.2 for easy understanding of the different components and their interrelations.

The context of vulnerability describes the external environment where poor people live (Antwi *et al.*, 2015; Shah *et al.*, 2013). This includes trends related to technology or population. It also encompasses shocks such as inflation or natural disasters and seasonality which refers to employment opportunities. All these factors influence the assets base of the poor.

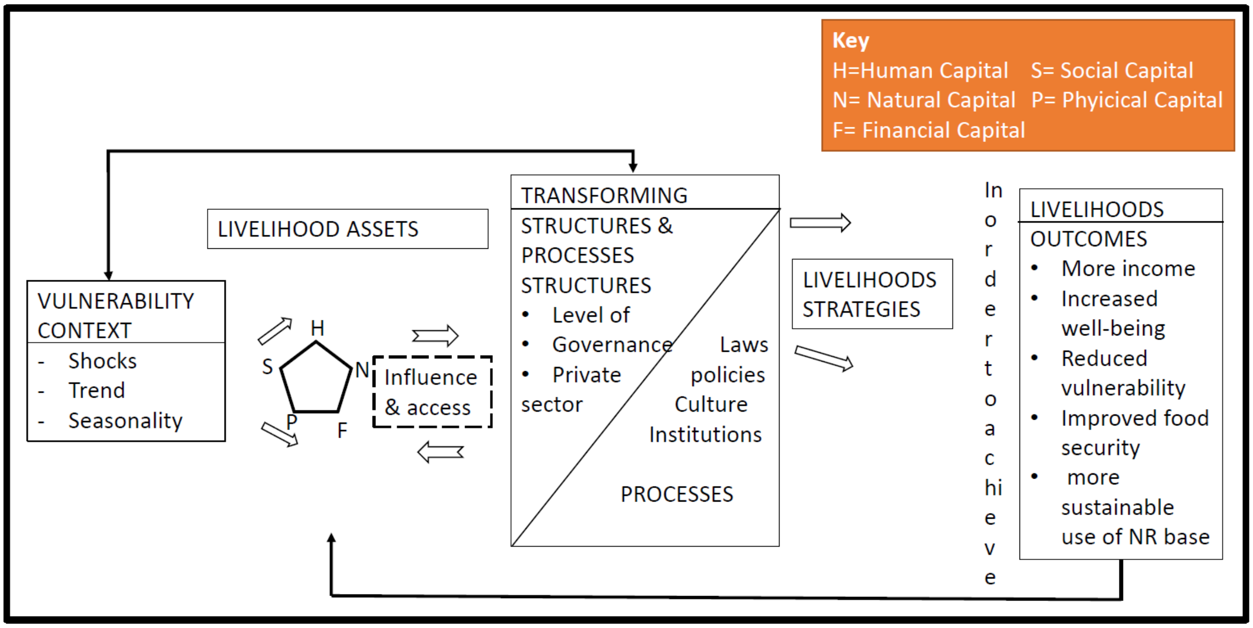

Figure 3.2: Sustainable Livelihood Framework

Source: DFID (2000)

The sustainable livelihoods model was developed on the assumption that people need different kinds of assets for meaningful livelihood outcomes (Chambers & Conway, 1991; Pandey *et al.*, 2017). These assets were classified as "Human capital referring to the knowledge, skills, ability and good health that will ensure people obtain their desired outcomes. Human (H) capital is essential for combination of other kinds of capitals for higher productivity. Social (S) capital refers to the social resources such as membership of groups, networking, or mere trust that exists between people that make them help each other. Natural (N) capital covers tangible resources such as trees, land and intangible products such as biodiversity and atmosphere. Physical (P) capital describes the basic infrastructure and producer goods. Financial (F) capital is the financial resources. Transforming structure and processes includes the policies and the institutions that frame the livelihoods of the poor. These processes determine the opportunities people have to different kinds of assets.

Livelihood strategies are defined by how people act to achieve the desired living standards. Livelihood outcomes are determined and achieved by strategies people adapt. The outcomes of SOGS that provide skills and information influence productivity, postharvest loss reduction, and profitability mimics the sustainable livelihoods framework in the sense that, skills and information can improve profitability and improve incomes which can influence assets accumulation leading to sustainable livelihood empowerment and less vulnerability to climate change.

3.4 Theoretical Framework for Factors Influencing Participation in Outgrower Scheme

Factors influencing smallholder farmers participation in SOGS is founded on utility maximization theory. From the utility perspective, SHF choice to participate in an intervention is influenced by their expected utility. Smallholder farmers are said to maximize their utility function, subject to their expected benefit against none participation (Aleskerov *et al.,* 2007)

In the Equation 3.1, the difference between the utility of participation (U_{pi}) and utility of none participation (U_{ni}) in OGS may be denoted as OGS^* such that utility maximizing farmer (i), will choose to participate, if the utility gained for participating is greater than the utility of not participating. This is expressed in linear function as

$$OGS^* = U_{pi} - U_{ni} > 0. \qquad (3.1)$$

Since these utilities are unobservable, they can be expressed as a function of observable elements in the following latent variable model in equation 3.2:

$$OGS^* = \beta X_i + u_i \quad \text{with } G_i = \begin{cases} 1 & if\ OGS^* > 0 \\ 0 & otherwise \end{cases} \qquad (3.2)$$

where OGS is a binary indicator variable that equals 1 if SHF participate in OGS and zero if otherwise

β is a vector of parameters to be estimated;

X is a vector of explanatory variables;

u is the error term.

The utility maximization theory can also be expressed as in equation 3.4:

$MAX\ (U)= f(x)$ (3.3)

Utility, U, is determined by a set of variables X. These variables influence the farmer's decision, ability and willingness to participate in SOGS and at the same time, influence the outcome variables where:

U= utility (3.4)

x= factors influencing decision to participate.

Given that the net utility is represented by U^*, $U^*= U_{ijt} > U_{imt}$ (3.5)

Farmer i will only participate in SOGS (j) at time (t) if the expected utility derived from participating (U_{ijt}) is greater than the expected utility (U_{imt}) of not participating.

Where:

$U^* =$ benefits of participating in j as opposed to not participating (m) while U^* is unobserved.

To determine factors influencing SHF participation in SOGS following utility maximization theory, a probit model was adopted. Common models for analysing binary dependent variable include discriminant analysis, the linear probability model, the probit model, and the logit model (Maddala, 1983)

Discriminant analysis is not suited for this analysis as it assumes that the explanatory variables are normally distributed. For the linear probability model, its limitation is the predictions could fall outside the interval (0,1) (Maddala, 1983). Results from probit or logit model are similar (Maddala, 1983). Following Maddala (1983), probit model was adopted to determine the factors influencing participation in SOGS.

The Utility Maximization theory has been applied in many studies to explain technology adoption and contract farming schemes in many parts of Africa. For instance, it was recently used by Ragasa *et al*. (2018) to analyze the limitations of maize contract farming as a pro-poor strategy in the Upper West Region of Ghana; determining agricultural technology adoption in Mozambique; farmers' response to adoption of commercially available organic fertilizers in Oyo state , Nigeria and determinants of adopting imazapyr-resistant maize for Striga control in Western Kenya (Ajewole, 2010; Mwangi & Kariuki, 2015; Ragasa *et al.*, 2018; Uaiene *et al.,* 2009).

3.5 Theoretical Framework for Effects of Sorghum Outgrower Scheme on Productivity, Postharvest Loss and Profitability

The theoretical foundation determining the effect of sorghum outgrower scheme on productivity, postharvest loss reduction and profitability is production theory. The production process involves combination of different factors of production into an output using a given technology (Choi, 2009). Agronomics measure crop productivity as the crop yield generated from a unit area of land, usually one hectare. Econometricians analysed productivity using econometric models such as data envelopment analysis, stochastic frontier approach, linear regression, propensity score matching and endogenous switching regression (Donkor & Owusu, 2019).

The stochastic frontier and data envelopment analysis are mostly applied to estimate productive efficiency, whereas linear regression, propensity score matching and endogenous switching regression are used to measure effect of a given variable of interest on a given outcome variable (Asfaw *et al.*, 2012; Lokshin & Sajaia, 2018).

Lokshin & Sajaia (2018) analytical approach, the sorghum productivity is examined with a generalised production function presented in equation (3.6):

$$PROD_i = f\left(X_{1i,}X_{2i,}X_{3i,} \dots, X_{jn}SOGS_{i,}X_{i,}\mathcal{E}\right) i = 1,2, \dots, N \qquad (3.6)$$

Where

$PROD_{i,}$= sorghum productivity per hectare

$X_{1i,}X_{2i,}X_{3i,} \dots \dots, X_{jn}$ = A set of factor inputs (seed, fertilizer, labour, seed, knowledge used for production)

f = The relationship of the various output and the factor inputs.

SOGS= denotes package of SOGS captured as a variable, 1 represents participation in SOGS and 0 not participating.

For profitability, this study extends the analysis of profit margin presented by Wünsch *et al.* (2012) in Equation 3.7 estimate profit by accounting for the differences of product of price per kilo and total cost (fixed cost plus variable cost per one hectare). Following Wunsche *eta al.* (2012),

Equation π_{ijk}= (CR_i +L_{ik} +DP-DC_{ij} -FC_i) H_i (3.7)

Where:

π_{ij}= average profitability

CR_i = average revenue per hectare for cropping year which is the sum of product of price and yield for a given crop

L_{ik} = is crop insurance indemnities per hectare for cropping system i and is the sum of indemnities for a given crops weighted by the share of area for the crop. The indemnity for a given crop is zero expect when the yield for the given year falls below the yield guarantee. DP= is direct payments per hectare, which are constant across cropping season, machinery complements.

DC_{ij} = Variable cost per hectare for cropping season i and farm size j. This include cost of fertilizer, seeds, labour, transportation, storage and land rental costs for cropping season i on a per hectare basis.

FC_i = fixed cost per hectare (machine ownership, land ownership, farm insurance and utility).

H_i = The number of hectares for cropping season i.

3.5.1 Estimation of Treatment effects of Outgrower Scheme on Productivity, Postharvest Loss and Profitability

In analysing the effect of SOGS on productivity, postharvest loss and profitability, impact evaluation assessment approach is adopted. Assessing the gains of using non-experimental observations has received criticisms for either over estimation or underestimation (Hausman, 1978; Heckman, 1979). The Criticisms are due to difficulty of controlling for observed and unobserved characteristics of the beneficiaries that might influence the outcomes of the intervention apart from the intervention itself. The reason being that, one cannot observe the gains of those who participated had they not participated (the counterfactual outcome) on most methodologies used.

In experimental projects, these problems are addressed using randomization. The SOGS participants are not randomly selected but rather, the outgrowers self-select to participate based on available information. The outgrowers and non-outgrowers may have differences in terms of both exogenous and endogenous characteristics that may or may not influence participation. Some of the known econometric approaches employed include Propensity Score Matching (PSM), Inverse Probability Weighted Ratio Adjusted (IPWRA) and Endogenous Switching Regression method (ESRM).

The essence of using PSM is to compare observable characteristics on treatment units with similar characteristics on the untreated units. Once the units are matched based on observed characteristics, PSM conclude no significant differences in their observable characteristics and therefore results obtained by comparing the two units is consistent and unbiased (Gitonga *et al.,* 2013; Rosenbaum & Rubin, 1983; Wooldridge, 2002).

The PSM can still generate biased results in the presence of mis-specification in the propensity scores. The potential remedy for such mis-specification is to use IPWRA. Regardless of matching techniques to adjust for mis-specification, it can only overcome selection bias due to observable characteristics. However, when the causes of selection bias are due to unobserved endogeneity such as farmer's inherent skill, the results based on matching techniques will still be biased (Asfaw *et al.*, 2012). The ESRM approach that accounts for both observed and unobserved biases by comparing counterfactual outcomes is considered superior for impact evaluation (Asfaw *et al.,* 2012; Donkor & Owusu, 2019; Lokshin & Sajaia, 2018). This study used ESRM to estimate treatment effects whiles PSM is used as complementary for robustness check.

3.5.1.1 Propensity Score Matching (PSM)

The PSM is a non-parametric method which constructs statistical similar group by modelling the probability of participating in an intervention on the basis of similar observed characteristics of the treated and untreated units that are unaffected by the intervention (Hausman, 1978; Heckman, 1979). Once the units are matched based on observables characteristics, PSM assumed no significant differences in the observable characteristics after the match and therefore, measure the average differences in the outcomes of the two comparable units (Caliendo, 2005; Gitonga *et al.,* 2013; Khandker *et al.*, 2010; Rosenbaum & Rubin, 1983)

Propensity score (P(X) = Pr (D = 1|X) = E (D |X)) is defined as the probability that a unit in the combined sample of treated and untreated receives the treatment, given a set of observed variables (French & Popovici, 2011; Rosenbaum & Rubin, 1983)

There are two assumptions that underlie the implementation of PSM (Caliendo, 2005; Rosenbaum & Rubin, 1983). These include conditional independence or unconfoundness assumption and common support assumption. The unconfoundness assumption implies that potential outcomes are independent of the treatment status assuming set of observed X covariates are controlled. The unconfoundness assumption is denoted as

$$(Y_1, Y_0) \perp D / X \tag{3.8}$$

Where $\perp$ denotes conditional independence. Potential outcome (sorghum crop productivity, farmers' postharvest loss reduction, profitability and vulnerability to climate change) of participation in the outgrower scheme is conditionally independent. This implies that the differences in outcome between participants in OGS and not participating is due to the effect of the SOGS (Caliendo, 2005). The common support condition implies that for individuals with the same value of X, there is a probability of either being in the SOGS or not being in the SOGS. This is specified as:

$$0<P(D=1/X)<1 \qquad (3.9)$$

This means that the probability of receiving treatment lies between 0 and 1. The common support condition ensures that participants and non-participants found adequate matches as a result of sufficient overlap in characteristics. If the common support is satisfied, it means that there are individuals who share the same pre-treatment characteristics across treatment and control group (Caliendo, 2005; Rosenbaum & Rubin, 1983).

Balancing test is then conducted to ensure that common support is satisfied. Various approaches used to assess the testing quality of the matching are: standardized bias (SB), the pseudo-$R2$ and the *t*-test (Caliendo, 2005). Following Rosenbaum & Rubin (1983) sensitivity test, the estimated effects on outcome indicators was tested to establish how strongly the unobservable variable influence the selection process to undermine findings based on matching on observables.

Type of matching approaches used by PSM are: nearest neighbour matching, radius matching, caliper matching, kernel matching and stratified matching (Caliendo, 2005; Gitonga *et al.*, 2013; Rosenbaum & Rubin, 1983). This study used nearest neighbour matching.

Nearest Neighbour Matching: The individual farmer from the treatment group compared with partner from the treatment group that has the closest propensity scores. Two main types of nearest neighbour matching are used. Matching ‘with replacement’ and matching ‘without replacement’. For the matching with replacement, the individuals in the treatment group can be used more than once as a match, whereas with the matching without replace case, the match is only considered once. With the matching with replacement, the average quality of matching increases and the bias also decrease (Rosenbaum & Rubin, 1983). This study used matching without replacement.

The average treatment effect on the treated (ATT) estimation was conducted to determine how the SOGS impact on farmers who actually participated. The average treatment effect on the untreated (ATU) was also conducted to establish how the SOGS would have had on the control group had they (the control group) participated.

3.5.1.2 The Endogenous Switching Regression Estimation

The ESRM can be estimated with one equation at a time, by either two-step least square or maximum likelihood estimation. Apart from these methods being cumbersome, they also produce inefficient estimation (Lokshin & Sajaia, 2018). The *movestay* command in stata is more robust in implementing full information maximum likelihood (FIML) to simultaneously estimate continuous and binary parts of the model to yield consistent standard errors by relying on joint normality of the error terms in the model (Lokshin & Sajaia, 2018). The FIML determines the influence of independent variables on participation and at the same time, also influencing the outcome variables. The *movestay* command can also determine the appropriateness of using the ESRM for the estimation through estimating the significance of the overall equation. Consider model 3.10 which describes the behaviour of treatment and control households with two regression equations and criterion function the treatment and control household faces.

$$\begin{cases} y_{1i} = \beta_1 x_{1i} + \varepsilon_{1i}\ if\ D_i^* > 1 & treatment \\ y_{0i} = \beta_0 x_{0i} + \varepsilon_{0i}\ if\ D_i^* \leq 1 & control \end{cases} \tag{3.10}$$

In equation 3.9, y_{1i} and y_{0i} are the welfare gains for treatment and control groups respectively. The x_{1i} and x_{0i} represent a vector of exogenous factors that are thought to influence participation. The $\beta_1 and\ \beta_0$ are the parameters to be estimated. $\varepsilon_{0i}\ and\ \varepsilon_{1i}$ and u_i (in the decision equation) are the stochastic disturbance from the outcome equations and selection equation. These variables are assumed to have a trivariate normal distribution, with mean vector zero and non- singular covariance matrix (Maddala, 1983).

$$\text{Cov}\ (\varepsilon_{1i,}\varepsilon_{2i,\mu}) = \begin{bmatrix} \sigma_{\varepsilon 1}^2 & . & \sigma_{\mu 1\mu} \\ . & \sigma_{\varepsilon 2}^2 & \sigma_{\mu 2\mu} \\ \sigma_{\mu\varepsilon 1\mu} & \sigma_{2\mu\varepsilon} & \sigma_{\mu}^2 \end{bmatrix} \tag{3.11}$$

$\sigma_{\varepsilon 1}^2$ and $\sigma_{\varepsilon 2}^2$ are variances of the stochastic disturbance terms in the treatment functions in equation 3.11. σ_{μ}^2 is the variance of the stochastic disturbance term in the selection equation. $\sigma_{\varepsilon 1\varepsilon_2}$ represents the covariance of the stochastic disturbance. while $\sigma_{\mu\varepsilon 1\mu}$ is the covariance of $\varepsilon_{1i}$and $u_{i.\sigma_{\mu 2\mu}}$ is the covariance of $\varepsilon_{2i}\ and\ u_i$. The covariance between $\varepsilon_{1i}$and ε_{2i} is not defined. y_{1i} and y_{0i} from equation 3.10 are not determined simultaneously and it is assumed that $\sigma_u^2 = 1$ because γ is estimable only up to a scalar factor (Maddala, 1983). A useful implication of the error structure is that the stochastic disturbance terms from the equations (3.10) are correlated with the stochastic disturbance term in the selection equation. Therefore, expected values of the stochastic disturbance terms from the functions in equation (3.10) conditioned on sample selection are not equal to zero as shown below

$$E(\varepsilon_{1i}\ /\ \ D_i = 1) = \sigma_{\varepsilon 1u}\frac{\emptyset(\beta x_{i)}}{\theta(\beta x_i\ )} = \sigma_{\varepsilon 1u}\delta_{1i} \text{ where } \delta_{1i} = \frac{\emptyset(\beta x_{i)}}{\theta(\beta x_i\ )} \tag{3.12}$$

$$E(\varepsilon_{1i}\ /\ \ D_i = 9) = \sigma_{\varepsilon 2u}\frac{\emptyset(\beta x_{i)}}{1-\theta(\beta x_i\ )} = \sigma_{\varepsilon 2u}\delta_{2i} \text{ where } \delta_{2i} = \frac{\emptyset(\beta x_{i)}}{1-\theta(\beta x_i\ )} \tag{3.13}$$

If the estimated $\sigma_{\varepsilon 1u}$ and $\sigma_{\varepsilon 2u}$ are statistically different from zero, the null hypothesis of absence of self-section is rejected. This suggests that the decision to participate in SOGS and the outcome variable are correlated, thus, existence of selection bias.

Conditional expectations, treatment and heterogeneity effects

Following Asfaw *et al.* (2012) and Donkor & Owusu (2019), the ESRM can compare expected effect of SOGS on productivity, postharvest loss reduction, profitability and vulnerability to climate of treatment group (a) in equation 3.14 with the effect on the control group (b) in equation 3.15 and to examine the expected outcomes of the same variables in the counterfactual hypothetical cases that the treatment group did not participate (c) in equation 3.16, and that the control group participated (d) in equation 3.17. The conditional expectations for the outcome variable in the four cases are presented in Table 3.1 and defined as follows:

$$E(Y_{1i}|D_i = 1, X_{1i})=\beta_1 x_{1i}+\sigma_{\varepsilon 1u}\delta_{1i} \quad (3.14)$$

$$E(Y_{2i}|D_i = 0, X_{2i})=\beta_2 x_{2i}+\sigma_{\varepsilon 2u}\delta_{2i} \quad (3.15)$$

$$E(Y_{1i}|D_i = 0, X_{1i})=\beta_2 x_{1i}+\sigma_{\varepsilon 1u}\delta_{2i} \quad (3.16)$$

$$E(Y_{2i}|D_i = 1, X_{2i})=\beta_1 x_{2i}+\sigma_{\varepsilon 2u}\delta_{1i} \quad (3.17)$$

Table 3.1: Treatment Effect

Sub sample	Decision Stage		Treatment effects
	Treatment	Control	
Farmers who participated in SOGS	(a) $E(Y_{1i}|D_i = 1)$	(c) $E(Y_{2i}|D_i = 1)$	On the treated ATT_i
Farmers who do not Participate in SOGS	(d) $E(Y_{1i}|D_i = 0)$	(b) $E(Y_{2i}|D_i = 0)$	On the untreated (ATU_i)
Heterogeneity effects	BH_{1i}	BH_{2i}	TH

Source: Asfaw (2012)

The outcomes (a) and outcome (b) represent observed outcomes while outcome (c) and outcome (d) represent their respective counterfactual expected outcomes. $D_i = 1$ if smallholder sorghum farmer i participate in SOGS and $D_i = 0$ otherwise.

Y_{1i} = sorghum farmers productivity, profitability, postharvest loss reduction or vulnerability of the sorghum farmer i participating in SOGS.

Y_{2i}= sorghum farmer productivity, profitability, postharvest loss or vulnerability to climate if the sorghum farmer i did not participate in SOGS.

ATT_i= the effect of the treatment (outgrowers) on the treated (outgrowers)

$$ATT_i=E(Y_{1i}-Y_{2i}|D_i=1)= \beta_1 x_{1i}+\sigma_{\varepsilon 1u}\delta_{1i}- \beta_1 x_{2i}-\sigma_{\varepsilon 2u}\delta_{1i}= \beta_1(x_{1i}-x_{2i})-(\sigma_{\varepsilon 1u}-\sigma_{\varepsilon 2u})\ \delta_{1i} \quad (3.18)$$

In similar manner, the effect of SOGS of the untreated (ATU) (non-outgrowers) is calculated as the difference between (d) and (b),

$$ATU_i=E(Y_{1i}-Y_{2i}|D_i=0)=x_{2i}(\beta_i-\beta_2)+(\sigma_{\varepsilon 1u}-\sigma_{\varepsilon 2u})\ \delta_{2i} \quad (3.19)$$

Heterogeneity effect: The farmers on SOGS may perform better than those who did not participate due to unobservable characteristics such as their skills, information and business orientation but not necessarily due to their participation in the SOGS (Asfaw *et al.,* 2018; Asfaw *et al.,* 2012; Carter & Milon, 2005; John Ng'ombe, 2013; Lokshin & Sajaia, 2018). Adapting Carter & Milon (2005) method in this case, "the effects based on heterogeneity" for participating farmers (BH_{1i}), can be defined as differences between (a) and (d) in Table 3.1. as:

$$BH_{1i}= E(Y_{2i}|D_i=1)-E(Y_{1i}|D_i=0)= \beta_1(x_{1i}-x_{2i}) + \sigma_{\varepsilon 1u}(\delta_{1i}-\delta_{2i}) \quad (3.20)$$

For the effect on no-participating farmers (BH_{2i}) in the SOGS, the heterogeneity effect is the difference between (c) and (b) as:

$$BH_{2i}= \text{E}(Y_{2i}|D_i=1)\text{-E}(Y_{2i}|D_i=0)= \beta_2(x_{1i}\text{-}x_{2i}) + \sigma_{\varepsilon 2u}(\delta_{1i}\text{-}\delta_{2i}) \quad (3.21)$$

Transitional Heterogeneity (TH) is calculated to understand the level of effect of SOGS on those who actually participated and those who did not or in the counterfactual case that they choose to participate. The TH is the difference between equations (ATT_i) and ATU_i.

3.6 The Effects of Sorghum Outgrower Scheme on Vulnerability to Climate Change

The study adopted the Livelihood Vulnerability Index (LVI) framework employed by the Intergovernmental Panel on Climate Change (IPCC) for analysing the vulnerability to climate change on both treatment and control groups. The IPCC define vulnerability as a function of exposure, sensitivity and adaptive capacity (Hahn *et al.*, 2009).

Vulnerability indicators offer useful means of recognising and monitoring vulnerability over time and identifying contributing factors to vulnerability and livelihoods outcomes (Bhattacharjee & Behera, 2018; Djalante, 2019; Hahn *et al.*, 2009). They provides a useful suggestions on classification of vulnerability into: adaptive capacity, sensitivity, and exposure (Shah *et al*., 2013). Adaptive capacity defines ability of a system to adjust to expected or actual climate stresses and to cope with the consequential effect. Adaptive capacity is a function of wealth, information, infrastructure, technology, education, access to resources, skills, stability and management capabilities (Adu *et al*., 2018).

Sensitivity denotes the degree to which a system responds to changes in climate variables. Exposure refers to the degree of climate related stress in a particular place which could be either a long-term change in climate conditions, or changes in the climate variability (Shah *et al*., 2013).

The Livelihood Vulnerability framework is therefore relevant to understand vulnerability to climate change because it provides a framework for analysing both the sub-components and major components that make up livelihoods and the contextual factors influencing them. Following IPCC definition of vulnerability developed by Hahn *et al.* (2009), seven major components were listed. They are "socio-demographic profile, livelihood strategies, social networks, health, access to food, access to water and natural disasters and climate change". Each of these components are made up of sub-components measured on a different scale. The LVI has been used by different authors to estimate SHF vulnerability to climate change (Adu *et al.*, 2018; Bhattacharjee & Behera, 2018; Etwire *et al.*, 2013; Hahn *et al.*, 2009; Shah *et al.*, 2013).

Having established vulnerability of the treatment and control group to climate change, the study then adopted the ESRM 3.5.1.2 and the PSM method for robustness test in 3.5.1.1 above to determine the effect of SOGS on reducing the vulnerability to climate change on both groups.

3.7 Method of Data Analysis

The data collected were analysed both quantitatively and qualitatively and integrated at the report writing stage in line with principles of mixing data. The quantitative data which was captured electronically using CAPI was transferred onto a platform and analysed using STATA. Qualitative data from interviews and focus group discussions were transcribed and analysed using NVivo Pro 11 software. In the report writing stage, quotations were used to emphasise key statements.

3.7.1 Background of the Study Respondents

Descriptive statistics were used to explain the background of the study respondents. Variables describing the outgrowers and non-outgrowers were generated and mean differences estimated using cheque squire test for categorical variables and t-test for the continuous variables. The first set of analyses examined the differences in means of farmers on outgrower scheme and non-outgrower members. The main areas of interest were their demographic characteristics, socio-economic characteristics, farm characteristics and other observable features. Information generated was presented in tables and diagrams and the mean differences between the two groups explained. A t-test was conducted and the significance of their mean differences was based on $p<0.05$. Variables which were found to be significant were thoroughly discussed.

3.7.2 Factors Influencing Smallholder Farmers Participation in Outgrower Scheme

Probit regression analysis was conducted to determine the factors influencing SHF participation in SOGS. The dependent variables which is participating in sorghum OGS is dichotomous (1 = Sorghum Outgrower, 0= Sorghum farmers not under the Outgrower Scheme). The probit model assumes existence of "latent" dependent variable, in this case the probability of participating in SOGS (Maddala 1988).

Consider the dependent variable y_i,

$$y_i = \begin{cases} 1 \ \ with\, probability\, P_i \\ 0\ with\, probability\ 1 - P_i \end{cases} \tag{3.22}$$

The probability of participating in the sorghum outgrower scheme, P_i, is assumed for any observation *i* by the probit function.

Y^{*}=βX_i +Ɛ, Ɛ ~ N (0, σ^2) (3.23)

Where,

Y^{*}= is the OGS

X_i is the independent variable,

β is the coefficient of estimation,

Ɛ is the error term.

The Empirical Model of the factors influencing sorghum farmers' participation in SOGS is specified as:

$$OGS = \beta_0 + \beta_1(Gen) + \beta_2(Age) + \beta_3(Edu) + \beta_4(HHs) + \beta_5(Mari) + \beta_6(Occu)$$

$$+\beta_7 Exp) + \beta_8(HHStatus) + \beta_9(Cred) + \beta_{10}(FBO) + \beta_{11}(Ext) + \beta_{12}(Fsize)$$

$$+\beta_{13}(Comyear) + \beta_{14}(Dist) + \beta_{15}(Leader) + \varepsilon \quad (3.24)$$

Where

OGS= Participation in the sorghum outgrower scheme which is the dependent variable of the regression.

β_0 =The intercept (constant),

β_0 to β_{15} are the Parameters to be estimated

ε = Disturbances term which is independent, identical normally distributed with zero (0) mean and constant variance Ɛ ~ N (0, σ^2). Having generated the results, only variables which were found to be statistically significant at $P < 0.05$ were discussed and their prior expectation interpreted.

3.7.2.1 Variables, Definition, Measurement Criteria and Prior Expectation

Table 3.2 contain variables influencing participation in the SOGS. Gender of a farmer has influence on participation in new agriculture intervention. In SSA, women and men are engaged in agricultural activities but women appear to be disadvantage in access to necessary productive resources to pursue activities with high-returns such as cash crop farming due to economic, social, physical and cultural barriers (Ali *et al.,* 2016; Anderson, 2019; Chigbu, 2019; Lambrecht, 2016; Lipton & Saghai, 2017; Wineman & Liverpool-Tasie, 2017).

Given that sorghum is a cash crop in northern Ghana and also given that women are disadvantaged in family resources and decision making, men are more likely to dominate in the sorghum outgrower scheme (Lambrecht, 2016; Mignouna *et al.*, 2011; Mwangi & Kariuki, 2015). This study anticipates less women to participate in OGS compared to men. Gender is measured as dummy.

Educational level of a farmer increases his ability to obtain, process and use information relevant to adoption of a new technology (Mignouna *et al.,* 2011; Mwangi & Kariuki, 2015). For instance, study by Okunlola, Oludare, & Akinwalere (2011) on adoption of new technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizer found that the level of education had a positive influence on adoption. This study postulates that the influence of formal education on participation would be positive. Level of education was measured by years of formal school completed starting from primary school class six.

Table 3.2 :Variables Influencing Participation in Sorghum Outgrower Scheme

Variable	Description	Measurement	Prior expectation
Demographic characteristics			
Gender	Sex of the farmer	Dummy (male=1, 0=female	+/-
Age	Years of the farmer	Number	
Edu	Educational status	Years in formal school completed	+/-
Labor	Adult household size people age (16 to 60)	Years	+
Mari	Married or not married	Dummy (marry=1, 0=not marry	+/-
Occu	The main occupation of farmer	Farmer=1, 0=otherwise	+
Exp	Number of years of farming	Years	+
Institutional factors			
Cred	Access to credit	Amount of credit received in the last 3 years	+/-
FBO	Belonging to farmer organization	Dummy (1=yes, 0=no	+/-
EXT	Number of extensions visit	number of days in season	+
Farm characteristic			
Fsize	Number of sorghum farms own	Hectares	+
Locational effect			
Dist	Distance from homestead to main market	Kilometres	+
Other factors			
ComYear	Number of years stay in the community	Years	+/-
Leadership	Leadership in social organization	Dummy (yes= 1, no=0)	+

Source: Author compilation (2018)

Age has negative influence in farmers' decision to participate in OGS and was measured by how old the farmers are in years (Ajewole, 2010; Al-Hassan *et al.,* 2013; John Ng'ombe, 2013; Koira Alemayehu Konde, 2014; Mauceri *et al.*, 2005; Udimal *et al.*, 2017). Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers will do. This wealth of information placed them in a position to make well informed decisions (Mignouna *et al.*, 2011).

Al-Hassan, Egyir, & Abakah (2013); Mauceri et al. (2005) and Mignouna *et al.* (2011), studies suggest that as farmers grow older, their risk aversion increase and they develop less interest in new areas of investment. Younger farmers on the other hand are typically less risk-averse and are more willing to try new technologies. Adoption of genetically modified maize for instance increased with age for younger farmers as they gained experience and increased their stock of human capital but declined with age for those farmers closer to retirement (Mwangi & Kariuki, 2015). Al-Hassan, Egyir, & Abakah, (2013) report on impact of ICT based market information shows that, for a unit increase in age, the likelihood of participation decrease by 0.5. Age in this study was measured by how old the farmers is and is predicted to have either negative or positive influence on decision to participate in the SOGS.

For the availability of farm labour, household size is used as a proxy. A larger household size is likely to have access to family labour (Ajewole, 2010; Mignouna *et al.*, 2011; Udimal *et al.*, 2017). It is hypothesized that farmers with more family labour have access to surplus labour. Household with surplus labour are more likely to participate in SOGS (Okunlola *et al.*, 2011). Labour availability was measured by the active population in the household (age 16-60). Farmers who are married are perceived as being more responsible and reliable in rural communities in northern Ghana. Reliable people are likely to be attracted for support such as credit and positively influence their participation (Awunyo-Victor & Al-hassan, 2014). This will have positive influence on their participation than farmers who are single. Marital status is specified as a dummy variable.

The main occupation of the respondent is explained by whether farming is the main occupation of the respondent or the respondent is only into farming to get additional income. According to Mariano *et al.* (2012), people who work in on-farm activities as their main occupation have a higher probability of participation in a new intervention than those on off-farm. This study expects positive relationship between farming as main occupation and probability of participation.

A farmer's experience may have negative or positive influence on participation. With more experience, a farmer can become more or less averse to the risk of OGS depending on the benefits or otherwise of OGS (Adesina & Baidu-Forson, 1995; Ahmed, 2014; Gebrezgabher *et al.*, 2015; Sakha, 2019). Experience is measured by the number of years of farming.

Household status refers to whether the respondent is the household head or otherwise. Some study found negative relationship between household head and participation in new intervention (Mustapha *et al.*, 2016; Nkegbe *et al.*, 2017). Due to responsibility of the household head in the study area to provide food for the entire family, this study anticipates negative relationship between household head and probability of participation.

Access to credit has been reported to stimulate technology adoption (Awunyo-Victor & Al-hassan, 2014). For SOGS, farmers with access to credit are able to improve their input access and meet contract requirements such as cost of fertilizer and improved seeds (AGRA, 2016; Awunyo-Victor & Al-hassan, 2014). Access to credit is hypothesised to have either negative or positive influence on decision to join SOGS. The unit of measurement was amount of credit received in the last three years.

FBO membership is likely to have positive influence on participating in SOGS (Ajewole, 2010; Feleke *et al*., 2017; ISSER, 2012; Maertens & Velde, 2017; Mwangi & Kariuki, 2015). Belonging to a social group enhances social capital allowing trust, ideas and information exchange (Mignouna *et al.*, 2011; Mwangi & Kariuki, 2015). Mwangi & Kariuki (2015) suggest that, the benefit of social network should not be underestimated and indicated that in the particular context of agricultural innovation, farmers learn from each other and the information from peer group may influence their adoption decision (Mwangi & Kariuki, 2015). Studying the effect of community-based organization in adoption of corm-paired banana technology in Uganda, Mwangi & Kariuki (2015) indicated that farmers who participated in community-based organizations were more likely to adopt the technology. Belonging to FBO is a dummy variable and is expected to influence decision to participate in SOGS positively.

Access to extension services has also been realise as key factor influencing farmers decision to adopt agricultural programme and for that matter, participating in OGS (Asfaw *et al.*, 2012; Azumah *et al.*, 2016; Feleke *et al.*, 2017; ISSER, 2012; MoFA, 2017b). Farmers are usually informed about the existence of new project as well as the effectiveness of a programme through extension agents. Access to extension agent acts as a link between the supplier and the farmer in identifying farmers for new project (Azumah *et al.*, 2016; Doss & Morris, 2001). The influence of extension agents can counter balance the negative effect of lack of years of formal education in the overall decision to adopt (Feleke *et al.*, 2017). The number of visits per farming season was used as proxy to access to extension services in this study. The effect of farm size on adoption of a new programme is anticipated to have positive relationship with adoption decision (Baiyegunhi *et al.*, 2019; Delbridge *et al.*, 2013; Ghimire *et al.*, 2015).

Years of stay in a community has similar effect on participation as the age of the farmer. Long stay in the community could be associated with comparatively, older age. The longer the farmers stay in the community, the lesser he/she is likely to participate in the SOGS (Sakha, 2019) .

Distance to the main market is used as a proxy for access to market. In a situation where there is ready market for sorghum without SOGS, farmers participation in OGS may reduce (Ebata & Hernandez, 2017b; Opoku, 2012; Villano *et al.*, 2019). Ready market will be measured by distance of farm to the nearest market. It is hypothesized that farmers whose farms are far from the main market are likely to participate in SOGS than those closer (Kiaya, 2018; Okunlola *et al.*, 2011; Tanellari *et al.*, 2011). This study hypothesized positive relationship between distance to market and probability of participation in SOGS. Distance to market is measured by kilometres from homestead to the nearest market.

Leadership in social organization is said to have positive relationship with participation. According to Ton *et al.* (2015), community leaders are usually the point of call for any new intervention and are sometimes, made part of the selection process in most rural communities and are more likely to participate. This study anticipates positive relationship between holding a leadership position in the community and the probability of participation.

3.7.3 The Effects of Outgrower Scheme on Productivity, Postharvest Loss Reduction and Profitability

Two approaches were adopted to achieve this objective. Sorghum productivity, postharvest loss and profitability was first estimated for both treatment and control groups without controlling for possible selection biased. This results only provide information on the outcome of SOGS but relying on such information to conclude on effects of the SOGS without addressing selectivity bias could be misleading due to observed and unobserved heterogeneity and endogeneity of individual farmers that could influence their participation decision and the outcome variables.

For instance, if participating farmers are naturally business oriented leading to their decision to participate in the SOGS and obtained higher profitability than non-participant, it is likely they would have equally performed better without being on the scheme. Concluding on the effects of the SOGS based on only the outcome variable could be misleading (Heckman, 1979).

To control for possible selection biases, endogenous switching regression model (ESRM) was used to estimate average treatment effect. The ESRM results are interpreted based on counterfactual outcomes which addresses both endogeneity and selectivity bias while PSM is conducted as a robustness check.

3.7.3.1 Productivity and Profitability Analysis

Following Wünsch *et al.* (2012), Delbridge *et al.* (2013), Montgomery *et al.* (2017 and Devkota *et al.* (2019), Sorghum productivity and profitability was calculated using total variable cost, area of production and price of sorghum in the 2017 farming season. The components of total variable cost ranges from cost of renting of land, cost of inputs and cost of hire labour and/or cost of family/communal labour (Montgomery *et al., 2017;* Devkota *et al.*, 2019*)*. Labour cost ranges from cost of land preparation, planting, fertilizer application, harvesting, carting, threshing/winnowing and cost of bagging and storage (Arslan *et al.*, 2017).

Information on the cost was obtained during focus group discussion, expert interviews and the survey interviews for members on the outgrower scheme and non-members of the schemes. The information provided was further confirmed from buyers and district Agricultural Extension Officers and from Guinness Ghana Brewery Limited. Unit of measurement was the new Ghana Cedis (GHS). The price of sorghum was calculated in GHS/kilogram. The reference year was 2017 major farming season since there is only one cropping season for sorghum in the study area. Yields were estimated in kilogram per hectare.

Using STATA version 15, the Average revenue, variable cost, productivity and profitability was calculated separately and compared for farmers on the treatment group and those on the control group.

3.7.3.2 Estimating Postharvest Loss for the Various Stages

The various postharvest loss stages are: losses during harvesting; during carting and heaping; during drying; during threshing/winnowing and during storage (Basavaraja *et al.,* 2007; Sheahan & Barrett, 2016). Average quantity loss and percentage loss were calculated along the various stages. The losses in the various stages was accumulated as total percentage loss

Estimating the Average Quantity Loss: in estimating the average quantity loss, quantity of sorghum (j) held (t_q) and lost (q_i) at each stage of the postharvest handling activities was specified by the respondents. Sorghum (j) *held* at the beginning of the postharvest management chain is expressed on per unit basis (50 kg bag of sorghum).

The average quantity (TQ_{ij}) lost, given n number of respondents at each ith stage of the chain is given by:

$$TQ_{ij} = \frac{\sum t_q}{n} \qquad 3.25$$

Where TQ_{ij} = Average quantity of sorghum loss

t_q = Quantity of sorghum loss

n = Number of respondents

Average market value of Loss: The market value of sorghum loss is estimated along each stage of the postharvest handling activities. The market value of sorghum loss is estimated as the product of average per unit and average quantity loss of sorghum (j) at each *i*th level. The market value of sorghum loss at each *i*th level is given by:

$$V = P_i Q_{ij} \qquad 3.26$$

Where:

V = Market value of sorghum loss at the *i*th stage of the postharvest handling activities

P_i = average price per unit of sorghum at the *i*th stage of the postharvest handling activities

Q_{ij} = Average quantity of sorghum lost at the *i*th stage of the postharvest handling activities

Average percentage loss along the chain*:* Percentage loss of sorghum is estimated as the ratio of mean quantity lost to initial mean quantity held as a percentage at each stage of the postharvest handling activities.

$$\%TQL = \left[\sum \left(\frac{Q_{ij}}{TQ_{ij}} \right) \right] * 100 \qquad 3.27$$

Where $\%TQL$ = Total percentage post-harvest loss of sorghum

Q_{ij} = average quantity lost at the *i*th stage of the marketing channel

TQ_{ij} = Average quantity of sorghum held

Following (Asfaw, 2012), we implored ESRM to estimate treatment effect of SOGS on postharvest loss reduction and used PSM for robustness check explained above.

3.7.4 Determining the effects of Outgrower Scheme on Smallholder Farmers Vulnerability to Climate Change

The approach to calculate the effect of SOGS on SHF vulnerability to climate are in two folds. The first approach was estimating SHF vulnerability to climate change using the IPCC-LVI. The second approach applied ESRM to estimate the treatment effect and PSM technique used for robustness check as explained on estimating treatment effect on productivity and profitability above.

3.7.4.1 Estimating Vulnerability Level of Smallholder Farmers in the Study Area

The Hahn *et al*, (2009) identified seven major components namely: "Socio-demographic profile, livelihood strategies, social networks, health, access to food, access to water and natural disasters and climate change" as contributing factors to vulnerability to climate change. Each component is made up of several indicators or sub-components, each of which is measured on a different scale (Hahn *et al.*, 2009). The sub-components are standardized using equation 3.28:

$$Index_{shi} = \frac{S_{h-}S_{\min}}{S_{\max-}S_{\min}} \qquad 3.28$$

Where S_h is the observed sub-component of indicator for household, $S_{\min}$ and $S_{\max}$ are the minimum and maximum values respectively, after each is standardized, the sub-component indicators are averaged using the index of each major component:

$$M_h = \frac{\sum_{i=1}^{n} index_{shi}}{n} \qquad 3.29$$

According to Hahn *et al.*, (2009) "M_h represent one of the seven major components [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Network (SN), Health (H), Food (F), Water (W), or Natural Disaster and Climate Variability (NDCV)] for household, h ; $index_{sh}$ represents the sub-components, indexed by i , that make up each major component, and n is the number of sub-components in each major component.

Once values for each of the seven major components for a household are calculated, they are averaged to obtain the household-level LVI" as:

$$LVI_h = \frac{\sum_{i=1}^{7} wM_i Mh_i}{\sum_{i=1}^{7} wMi} \qquad 3.30$$

This can also be expressed as

$$LVI_h = \frac{w_{SDP}SDP_h + w_{LS}LS_h + w_H H_h + w_{SN}SN_h + w_F F_h + w_W W_h + w_{NDC}NDC_h}{w_{SDP} + w_{LS} + w_H + w_{SN} + w_F + w_W + w_{NDC}} \qquad 3.31$$

The weights of each major component, w_{Mi}, are determined by the number of sub-components that make up each major component and are included to ensure that all sub-components contribute equally to the overall LVI. The LVI was scaled from 0 low vulnerable to 1 extremely vulnerable (Hahn *et al.,* 2009).

Table 3.3: Major and Sub-Component for Natural Disasters and Climate Change

"Major Components	Sub-components	Measurement
Water	Percent of household reporting water conflict	Percent
	Percent of household that utilize a natural water source	Percent
	Average time to water source	Minutes
	Percent of household that do not have a consistent water supply	Percent
	Inverse of the average number of waters stored per household	1/litres
Socio-demographic profile	Dependency ratio	Ratio
	Percent of female- headed household	Percent
	Average age of female-headed household	Years
	Percent of household where head of household has not attended school	Percent
	Percent of households with orphans	Percent
Livelihood strategies	Percent of households with family member working in a different community	Percent
	Percent of households dependent solely on agriculture as a source of income	Percent
	Average agricultural livelihood diversification index	1/# livelihood
Social Network	Average receive: give ratio	Ratio
	Average borrow: lend money ratio	Ratio
	Percent of households that have not gone to their local government for assistance in the past 12 months"	percent

Source: Hahn *et al.* (2009)

Table 3.4: Major and Sub-Component for Natural Disasters and Climate Change

“Major Components	Sub-components	Measurement
Health	Average time to health facility	Minutes
	Percent of households with family member with chronic illness	Percent
	Percent of households where a family member had to miss work or school in the past 6 months due to illness	Percent
	Average malaria exposure*prevention	Month*Bednet indicators
Food	Percent of households dependent solely on the family farm for food	Percent
	Average number of months household struggle to find food	Number
	Average crop diversity index	1/# crops
	Percent of households that do not save crops	Percent
	Percent of households that do not save seeds	Percent
Natural Disaster and Climate variability	Average number of flood and drought events since 2000	Count
	Percent of households that did not receive a warning about natural disaster	Percent
	Percent of households with an injury or death as a result of flood or drought since 2000	Percent
	Mean standard deviation of monthly average maximum daily temperature since 1983	Celsius
	Mean standard deviation of monthly average minimum daily temperature since 1983	Celsius
	Mean standard deviation of monthly average precipitation since 1983	Millimeter”

Source: Hahn *et al.* (2009)

The climate variability is measured by the average standard deviation in monthly minimum and maximum temperatures and monthly rainfall over 30-year period (Hahn *et al.*, 2009). When the LVI for the major component computed and the sub-components are calculated for the treatment and control groups, student t-test (2-tailed) was employed to test whether there is a significant difference between the means of the LVI or not

3.7.4.2 Using LVI-IPCC Framework to Estimate Vulnerability

Hahn *et al*. (2009) further developed an alternative method for assessing vulnerability by estimating contributing factors to vulnerability in Table 3.5. This approach reorganised the seven major components of vulnerability into Exposure, Sensitivity and Adaptive Capacity.

Exposure is measured by the number of natural disasters that have occurred and climate variability.

Adaptive capacity is measured by the demographic profile, the types of livelihood strategies employed and the strength of social networks.

Sensitivity is measured by the state of food, water and health status.

Table 3.5: Factors Contributing to Vulnerability

Contributing factors to climate change		Major component
I.	Exposure	Natural disasters and climate variability
II.	Adaptive Capacity	1. Socio-Demographic Profile 2. Livelihood Strategies 3. Social Networks
III.	Sensitivity	1. Health 2. Food 3. Water

Source: Hahn *et al.*, (2009).

The equation 3.49 explains how LVI-IPCC is calculated.

$$CF_d = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{mi}} \qquad 3.32$$

Where CF_d is an IPCC-defined contributing factor (Exposure, Sensitivity and Adaptive Capacity) for community d.

M_{di} are the major components for community d indexed by i,

W_{Mi} is the weight of each major component,

n is the number of major components in each contributing factor.

Once Exposure, Sensitivity, and Adaptive Capacity were calculated, the three contributing factors are then combined using equation 3.50

$$LVI - IPCC_d = (e_d - a_d) * S_d \quad 3.33$$

Where $LVI - IPCC_d$ is the LVI for community *d* expressed using IPCC vulnerability framework, *e* is the calculated exposure score for community *d* (equivalent to the natural disaster and climate variability major component),

a is the calculated adaptive capacity scores for community *d* (weighted average of the socio-demographic Livelihoods strategies, and social network major component), and *s* is the heath, food and water major components).

The LVI-IPCC is then scaled between -1 (least vulnerable) to 1 (most vulnerable).

When the LVI-IPCC are calculated for the treatment and control groups, student t-test (2-tailed) was employed to test whether there is a significant difference between the means or not.

3.7.4.2 The treatment effects of Sorghum Outgrower Scheme on Vulnerability to Climate Change

Following Asfaw (2012), the ESRM explained in 3.5.1.2 was employed whiles PSM explained in 3.5.1.1. is used as robustness check to determine the effects of SOGS on smallholder sorghum farmers vulnerability to climate change.

3.8 Method of Data Collection

3.8.1 Sources of Data, Instruments and Interview Procedure

The main sources of data for the study was secondary and primary data sources. The secondary data source focused mainly on documentary analysis of published and unpublished literature. Time series data from the Ghana Meteorological Agency was also sourced. The variables of interest were rainfall and temperature. This was needed to help establish the changes that have occurred overtime to help in determining vulnerability to climate change. The primary data source targeted stakeholders ranging from sorghum farmers, extension officers, MoFA officers, Sorghum Aggregators and institutions supplying sorghum to GGBL.

In view of the limitations of dichotomous qualitative and quantitative approaches, the mixed-method of data collection approach was used to compensate for the inherent limitations of using single method and also, to broaden the scope of the study to include different actors in the sorghum value chain. Irrespective of the challenges associated with such a triangulation of methods such as time constraints, high research costs, and conflicting data from different sources, combination of qualitative and quantitative methods was considered most appropriate for this study.

3.8.2 Sampling Procedure

Based on the existence of sorghum outgrower scheme, purposive sampling was first used to select Upper East and Upper West regions of Ghana. Eventhough sorghum is cultivated in Northern Region, Brong Ahafo Region and Volta Region, there are no SOGS actively operating in those regions. At the district level, one district each from the Upper East and Upper West regions were selected purposively based on practice of SOGS. Garu district in the Upper East Region and Jirapa district in the Upper West region were selected. Using the 2017 data of SOGS from Guinness Ghana Brewery Limited, communities in Garu district and Jirapa district that grow sorghum were listed and stratified. In Garu district, 10 communities were on the treatment stratum and 10 on the control stratum. In Jirapa district, 5 communities were on the treatment stratum and 15 communities on the control stratum.

Simple random sampling based on lottery approach was then used to select two communities each from each of the stratums. Zari community and Guzeig community in Garu district were selected from the treatment stratum. Bugri and Tubong communities from the control stratum were also in Garu district. In the Jirapa district, Sabuli and Chapuri communities were selected from the treatment stratum and Tizza and Kuncheni communities were selected from the control stratum.

A total of 516 households were sampled from both the treatment and control groups for the study using Yamane sampling formula. Having obtained four treatment communities and four control communities from treatment and control communities respectively, the systematic randomization was used to obtain 216 households from the list of 998 sorghum households from the treatment communities. For the control communities, 1,499 households growing sorghum were listed from the district agricultural extension officers in Garu and Jirapa districts combined. Systematic random sampling was used to sample 300 households from the control communities from the list provided. Note that Yamane (1967) formula had already been used to obtain the total sample size for the study.

Using the 2010 Population and Housing Census District Analytical Reports in Garu district and Jirapa district, the combined total number of households in the study area was 28,226. Using the Yamane (1967) simplified formula to calculate the sample size at 95% confidence level and assuming maximum variability to be 0.5 (p=5) with a 5% level of precision, the equation is assumed as follows:

$$n = \frac{N}{1 + N(e)^2} \qquad 3.34$$

Where n is the sample size, N is the households in the study communities, and e is the level of precision. When this formula is applied the results is as follows:

$$n = \frac{28{,}226}{1 + 28{,}226(0.05)^2}$$

$\frac{28{,}226}{1 + 71.565}$ = 394 households

Considering the design of the study (quasi-experimental), the control group was oversampled. A total of 516 respondents were targeted considering the interview period of 60 days. Enumerators over interviewed by 16 in the treatment communities. The treatment sample size is 216 and Control sample size is 300. This sample is considered a good representative sample (Yamane, 1967).

Table 3.4: Sampling Procedure

Stages	Sampling method	Sampling approach and sample areas
1	Purposive	Two regions in Northern Ghana (Upper East and Upper West) were selected based on sorghum production and existence of SOGS (MoFA, 2018).
2	Purposive	Garu and Jirapa districts were selected based on information of sorghum production and existence of SOGS.
3	Stratification	Communities were stratified into treatment and control communities in each district.
4	Lottery approach	In Garu, Zari and Guzeig were randomly selected from the treatment stratum and Bugri, and Tubong from the control stratum. In Jirapa, Sabuli and Chapuri were selected from the treatment stratum and Tizza and Kuncheni from the control stratum.
5	Systematic random sampling	Total list of 998 sorghum households on OGS were obtained from FBOs in the respective treatment communities. From the calculated sample size, systematic random sampling was then use to obtain 216 households
6	Listing	For the control communities, 1,499 households were listed. Systematic random sampling was used to obtain 300 households after calculation of sample size was done.

To ensure representativeness of sample size in each community, the proportional sampling was applied to obtain sample size for each community. The number of total households obtained was proportionally distributed based on the number of households for each community as shown in the table 3.8 below.

Table 3.5: Communities and Number of Sorghum Farmers Sampled

Treatment Status	Community	Sample Size
	Garu District	
Treatment	Zari	62
	Gozeig	58
Control	Tubong	131
	Bugri	50
	Jirapa District	
Treatment	Chapuri	45
	Sabuli	51
Control	Kuncheni	40
	Tizza	79
Total		516

Source: Field Survey (2018)

3.8.3 Interview Procedure

The data collection started on 5th August 2018 and ended on 30th October 2018. Prior to the field visit, community leaders (Assembly Members and Chiefs) in the study areas were consulted and informed about the purpose and content of the research. Engaging them helped to get their support in organizing the communities for the interviews. As customary demands, cola-nut and alcoholic drink popularly called, "*Akpeteshie"* were offered in each community as part of the community entry before explaining the purpose of the visit.

Qualitative Interview. The purpose of the qualitative interviews was to understand the farmers' farming experience; their perception and belief systems about the outgrower scheme; constraints and opportunities in sorghum farming; their relationship with other actors such as buyers and their everyday social worlds and realities. Information generated from the qualitative interviews helped to better understand the sorghum production and the outgrower arrangement which helped to review the survey questionnaire. The two main qualitative data collection method were Focus Group Discussions (FGDs) and in-depth interviews.

The Focus Group Discussion (FGD): The purpose of the FGD was to provide natural setting for various categories of farmers to openly discuss issues surrounding sorghum production. In all, eight FGD were carried out. In each community, one FGD was held with each different groups of men, women and the youth. The participants in each group ranged between 7-12 farmers. Treatment groups were interviewed in the treatment communities comprising of only the farmers who participate in the SOGS while control groups were held in the control communities for farmers who grow sorghum but do not participate in the SOGS.

The FGDs were held before the in-depth interviews to ensure that important issues were identified for further probing. The FGDs covered several issues including: types of farming practices in the community; the current architecture of agricultural investments; history of sorghum farming in the community; average farm size; knowledge in SOGS; SOGS package; contractual arrangement between farmers and buyers; their farming constraints; productivity issues; harvest and postharvest management practices; climate change experiences over the past 30 years; support given to farmers as part of the SOGS package to reduce vulnerability to climate change and resilience strategies. The role of SOGS in climate change adaptation were intensively discussed. Equally, the perception of non-participants and their view on the SOGS was also interrogated among the control groups.

In-depth Interviews: Purpose of the in-depth interviews was to explore information and new themes to improve the survey questionnaire. Semi-structured flexible interview guides were used to solicit information from respondents. Most of the interviews were conducted in the local languages and recorded electronically. Interviews with agricultural staff and GGBL was in English language. All interviews were face to face.

The respondents interviewed were officers of District Department of Agriculture, lead sorghum farmers, sorghum buyers and firms that were buying and supplying sorghum for GGBL. Specifically, five farmers who have expert knowledge in sorghum production in each community were interviewed. Two small size sorghum aggregators, two medium aggregators, one large aggregator and one supplier from each of the districts were interviewed. One officer from GGBL was also interviewed to understand the history and their perspectives of the SOGS.

Quantitative Interviews: The survey questionnaires were administered by five trained research assistants who understand and could speak the language of the people. For Garu, the predominant languages spoken are Kusaal, Bimoba and Mampruli and for Jirapa, Dagaare and Wale. The well-structured close-ended questionnaires were first computed into *Computer-Assisted Personal Interviewing* (*CAPI*) software. The questionnaires were reviewed severally to ensure that, information generated addresses the research objectives. All the questions were thoroughly discussed with the research assistants and translations done in the respective local languages. Pre-testing of questionnaires was conducted to examine the adequacy of the questionnaire, the sequence and how the respondents understood the questions and to evaluate whether the questionnaire would pose any challenge.

Pretesting of the Questionnaire: The Pre-testing of the survey instruments is one of the basic requirements for professional research. The experience from the pre-testing was used to improve the final survey questionnaire. The two days pretesting was conducted on the 20th and 21st August, 2018. One district (Garu) was purposively selected for the pre-testing.

Worikambo community and Kpatia community were selected to represent treatment and control communities respectively.

A total of thirty (30) households producing sorghum were interviewed. Fifteen (15) of the households were from Worikambo where SOGS is practiced and they were randomly selected from a list of outgrowers provided by the Garu-Tempani Farmers Associations. Fifteen (15) non-outgrower households were also selected from Kpatia community randomly according to the willingness to participate in the study. These communities eventhough were in Garu, they were not part of the targeted communities for the main research.

The pretesting helped to modify some of the questions. For example, prior to the pretesting, question on labour used: "*do you hire labour?* The options were yes or no. There was no provision for communal labour. This was reviewed to include communal labour.

Time Series Data: time series data on rainfall and temperature was collected from the Ghana Meteorological Agency for the last 30 years. This data was collected from Garu and Hang. Eventhough Hang is not one of the study districts, lack of weather station in Jirapa makes it impossible to get rainfall and temperature information from Jirapa. However, Hang is the nearest district to Jirapa that has weather station.

3.9 Study Area

This study was carried out in the Upper East and Upper West regions of Ghana where sorghum is largely produced. While *Faranaya*, a subsidiary company of Presbyterian Agricultural Station and *Akuafo Nketewa* Company Limited, a subsidiary company of the Peasant Farmers Association Ghana leads in the aggregating of sorghum in the Upper East Region, Agriaccess Company Limited leads the aggregation activities in the Upper West region. There are other ten smaller aggregators supplying to GGBL. The two regions have the highest level of poverty in Ghana, with 70.4% and 44.4% of the population in Upper West and Upper East Region respectively living below the poverty line in 2013 (Cooke, Hague, & Mckay, 2016; GSS, 2014c, 2014d).

Socio-economic Characteristics: Both regions are predominantly rural and depends largely on subsistence farming as their main economic activity (GSS, 2014b, 2014a). The main crops cultivated are maize, rice, groundnuts, millet, sorghum and vegetables. Livestock such as cattle, goats, sheep and pigs are also kept. Poultry, especially domestic fowls and guinea fowls are predominant in the regions (MoFA-SRID, 2016). Weaving, hunting and dry season gardening is popular activities of men during dried seasons, whiles the women engaged in petty trading, backyard gardening and basket weaving (GSS, 2014a, 2014b). Other areas that offer employment to the people are public service, food processing, textile and leather works (GSS, 2014b, 2014a).

Geographic Characteristics: The regions fall within semi-arid Guinea and Sudan Savannah zones which correspond to the north-eastern part of Upper East region whilst the Guinea Savannah is made up of the Upper West region and Northern region (GSS, 2014b, 2014a, 2014c). The Guinea Savannah has a short unimodal tropical monsoon, with a mean annual rainfall of 1,100 mm and a rainy season lasting between 180–200 days (GSS, 2014b, 2014a). The Sudan Savannah has a lower mean annual rainfall of 1,000 mm and between 150–160 rainy days. This is followed by 180 to 210 dry days (November to mid-April) characterised by dusty harmattan winds between November and February and a high temperature of 35 degrees centigrade during the day time (GSS, 2014b, 2014a). The long dry season coupled with the inadequate number of irrigable dams contribute to the seasonal migration of the youth from these regions to southern sector of Ghana in search of menial jobs (Cooke *et al.,* 2016). Garu and Jirapa districts have the highest sorghum production in Upper East and Upper West Region respectively (MoFA, 2017a). The treatment communities have the highest concentration of outgrower schemes based on 2016 official data from the district department of agriculture and Guinness Ghana Brewery Limited.

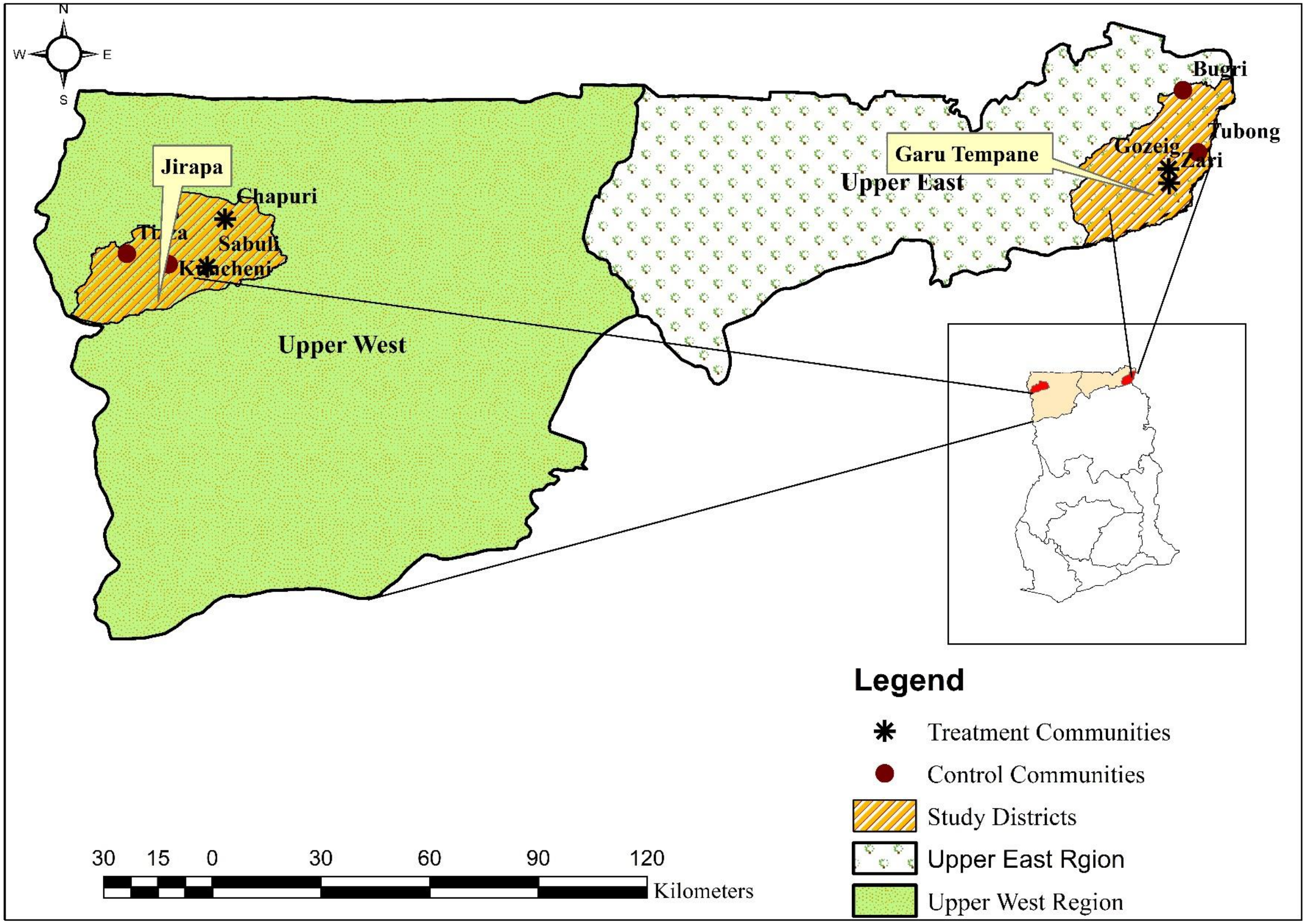

Figure 3.3: Map of the Study Area

Source: RS/GIS lab (2018)

3.10 Scope and Limitations of the Study

The study determines the effects of SOGS on SHF profitability, postharvest loss reduction and their vulnerability to climate change. Treatment group and control group were targeted for the study and their performance in sorghum production were compared. A particularly limitation of this approach is selection bias or farmers may choose to participate on the basis of both observed and unobserved characteristics that could also influence their outcome variables apart from the SOGS. To address the selectivity bias, the ESRM used counterfactual outcomes to compare performances. More robust results could be achieved in future with experimental design of which farmers would be randomly selected to participate. Comparing performance of such farmers with non-participates could provide more robust results.

The second limitation is using cross-sectional 2017 data for the study. Given that farmers in the study area relied on rainfall which is beyond their prediction, in the year of bad rains, the results might be different and present a different picture of sorghum performance under SOGS. Using panel data covering different years could provide more superior information. Given the time frame and the resources available, this study could not collect panel data. To compensate for lack of panel data, the qualitative interviews conducted allowed households to recall developments in the previous years.

To determine the effects of SOGS on SHF vulnerability to climate change, data on SOGS package that addresses SHF vulnerability to climate change was solicited based on 2017 information by the respondents. Comparing the 2017 performance with changes over 30 years may not provide consistent information. To address the inconsistencies, recall information was solicited during FGD and expert interviews to compensate for lack of panel data.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter is divided into four main sections. The first section highlights the background of the study respondent, farmers perceptions about the outgrower scheme, contractual arrangement and the kind of support received from the SOGS. The second section presents the probit regression results on factors influencing SHF participation in the SOGS. The third section presents the results of sorghum productivity, postharvest loss reduction and profitability for participating in the SOGS and the effects of SOGS on the outcome indicators (sorghum productivity, postharvest losses and profitability). The final section present results of IPCC-LVI for treatment and control groups vulnerability to climate change and the effect of the SOGS on reducing their vulnerability level.

4.2 Background of the Study Respondents

Background of the study respondents are in table 4.1 to table 4.3. The Table 4.1 contain household characteristics of variables for treatment and control groups. Table 4.2 contain farm characteristics and Table 4.3 present market, community and socio-economic and political characteristics.

4.2.1 Household Characteristics of the Respondents

Table 4.1 contain results of household characteristics of respondents in the study area. The results show differences in means of gender, age, education, non-farm livelihoods and farming experience between treatment and control groups. On gender of the respondents, 68% of the respondents producing sorghum were male farmers. About 71% and 65 % respectively of the male respondents were in the treatment and control groups respectively. This result support several literature on male farmers being likely to engage in cash crop production compared to their female counterparts (Ali *et al.*, 2016; Anderson, 2019; Chigbu, 2019; Lambrecht, 2016; Lipton & Saghai, 2017; Wineman & Liverpool-Tasie, 2017). The finding corroborates Tanellari *et al.* (2011), Mariano, *et al.* (2012) and Ragasa *et al.* (2018) studies which found more male farmers adopting new technology that require land, labour and other resources than female farmers.

Table 4.1: Household Characteristics of the Respondents

Variable	Treatment N= 216	Control N= 300	Overall N= 516	Difference (means)	P-values (chi-square/ t-test)
Gender (Male %)	71.3	65.3	68.3	6.0	0.153
Age of farmer (number of years)	46.6	50.1	48.4	3.4	0.014**
Educational level					0.780
No formal education (%)	63.9	77.7	70.8	-13.8	
Basic (%)	19.0	14.3	16.7	4.7	
Higher than Basic (%)	17.1	8.0	12.6	9.1	
Marital status (% married)	87.0	83.3	85.2	3.7	0.640
Experience in sorghum farming (years in farming sorghum)	5.8	9.1	7.5	3.3	0.000***
Household Size (no. of people in the household)	5.6	6.16	5.9	0.6	0.039
Farm Dominant livelihood (%)	88.9	90.0	89.5	1.1	0.120
Non –farm dominant livelihoods (%)	38.9	13.7	26.3	25.2	0.000***
Length of stay in the Community (years)	28.9	34.6	31.8	5.7	0.000***

****, ** and *** denotes significance at 10%, 5% and 1% respectively***

Source: Field Survey data (2018)

According to Abdul-Razak & Kruse (2017), the land tenure systems in northern Ghana favours male farmers. Since sorghum is a cash crop and requires separate land, this could be a barrier that limits participation of the female farmers. Land is a crucial resource in the efforts to bridge gender disparity in most rural areas. In northern Ghana, cultural barriers restrict women from negotiation for land on their own without their husbands. A study by Lambrecht (2016) in Ghana found that women in some rural communities in the Upper East region cannot negotiate land for economic activities on their own without their husbands involvement. Land access by women has serious implication on agricultural activities of women and require policy review to ensure that women can independently own and use their lands in a way that benefit them.

Majority of farmers on the treatment group are relatively younger with an average age of 46 years compared to 51 years for those in the control group. The result is similar to Al-Hassan *et al.* (2013); Maertens & Velde (2017) and Udimal *et al.* (2017) studies on older farmers less likely to adopt new technology compared to relatively younger ones. Udimal *et al.* (2017) further asserted that longer period of farming correlate with age and experience, hence, relatively older farmers are most likely to be content with their own ways of farming. As a 68-year old farmer from Bugri community in Garu districts characterises new schemes during an individual face-to-face interview "*I am not interested in these things [sorhgum outgrower scheme]. We had similar projects in the 1990s in cotton and it collapsed. I lost a lot of money when the cotton company at the time refused to buy the cotton they themselves asked us to grow. At my age, my concern is how to feed my three wives and children. It is food that matters to me most not money"*.

Similar sentiments were also expressed by a 64-year old farmer from Tizza community in Jirapa districts during FGD. *"I heard the support Pastor Anthony [*Anthony is the CEO of Agri-access limited that lead the SOGS in the Jirapa district*] is giving to farmers to produce sorghum for him to buy, but I am not interested. Today when you go to Sabuli, all their millet and groundnut farms have been converted for sorghum production. Eventhough sorghum will give you the money, what about food for the family? I have advised my children never to do that because it can lead to hunger in the future. A family is happy when there is enough food in the house. How much money will you get from sale of sorghum to be able to buy food for the family throughout the year?"* She concluded.

Old farmers' lack of interest in new schemes could be explained mainly by two factors. First, they are risk averse. This risk aversion is often underpinned by experiences with similar schemes in the past. Perceived unknown long-term beneficial outcomes of new interventions are often ranked high among older people (Sakha, 2019). Secondly, older people perhaps would probably not adopt new approach of farming because they possibly believed that conventional ways of farming are still better (Gebrezgabher *et al.,* 2015).

On educational level, both members of the treatment and control groups have low level of education. Overall, 72% of the respondents have never been to school, while 64% and 78% of control and treatment groups respectively have never been to school. About 19% of control group have basic education while 14% of control groups had at least basic education; 17% and 8% of members in the treatment and control groups respectively had education higher than basic school. This results is similar to several literature on low level of education among SHF (Dzanku, 2015; Ghimire *et al.*, 2015; Jolly *et al.,* 2006; Makate *et al.,* 2019; Mariano *et al.,* 2012; Tsinigo & Behrman, 2017). Farmers on the treatment group are slightly less experienced in farming than farmers in the control group with years of farming between 6 years for treatment group and 9 years for the control group. Both groups have average household size of 6. The number of years of farming could correlate with experience in farming, hence confirming the earlier findings of relatively younger people being on the treatment group.

On length of stay in the community, control group appears to stay in the community for longer period of 35 years compared with 28 years for the treatment group. Farmers who stayed in the community for long are less likely to participate compared with those who live in the community for relatively shorter period. It is possible those who live in the community for relatively shorter period migrated to those communities for farming activities.

Majority of farmers (about 90%) depend mainly on agriculture as their primary source of livelihood. Even though 28% and 14% of treatment group and control group respectively diversified their income sources. This finding also support literature that most SHF depends on agriculture for their livelihoods (Darfour & Rosentrater, 2016; WFP, MoFA, 2012; Yaro, 2013).

4.2.2 Farm Characteristics of the Respondents

Table 4.2 contain variables that explain farm characteristics for both treatment and control groups. The average land size reported is 0.8 hectares. The treatment group has relatively larger land size of 1hectare on average compared to 0.7 hectares for the control group. An average of 92% of respondents were farming on family land and 3% farm on land they have purchased. About 2% and 4% respectively from treatment and control groups farm on rented land and also land belonging to others without paying for it.

On the type of sorghum seeds cultivated 66% and 33% of *dorado* and *kapaala respectively* was cultivated by the treatment group compared to 53% and 9% respectively for control group. About 1% and 2% respectively cultivate Naga white. About 36% of control group cultivate *kadaga* and no farmer in the treatment group cultivates *kadaga*. Dorado and Kapaala are new improved sorghum variety preferred by GGBL for brewing. They are also early maturing and high yielding variety, especially the dorado. Kadaga and Naga white are the old sorghum varieties with long maturity period. Both varieties are not preferred for brewing by GGBL.

The high percentage of treatment group cultivating dorado and kapaala which is preferred by GGBL confirmed OGS condition of buyers determining the type of produce that farmers should cultivate (Brigitte & Ragasa, 2018).

Table 4.2. Farm Characteristics of the Respondents

Variable	Treatment	Control	Overall	Difference in means	P-value (T-test /chi-square)
Farm Size (Ha)	1.0	0.7	0.9	0.3	0.066
Land Ownership					0.382
Family land (%)	92.59	91.67	92.1	0.9	
Purchased land (%)	1.39	3.33	2.4	-1.9	
Rented land (%)	1.39	2	1.7	-0.6	
Land owned by others (%)	4.63	3	3.8	1.6	
Fertiliser application (%)	79.2	54.7	67.0	24.5	0.000***
Variety of seeds cultivated					0.000***
Naga white (%)	0.9	2.0	1.5	-1.1	
Kadaga (%)	0.0	36.0	18.0	-36.0	
Kapaala (%	33.3	9.0	21.2	24.3	
Dorado (%)	65.7	53.0	59.4	12.7	

***, ** *and* *** *denotes significance at 10%, 5% and 1% respectively*

Source: Field Survey data (2018)

With regards to the sources of seeds, an average of 86% of the respondents used their own saved seeds, 10% purchased seeds and 2% get seeds as part of SOGS package. Less than 1% get seeds from government and other sources such as friends and relatives; 18% of treatment group purchased seeds and 5% of control group purchased seeds. As part of government support through the *Planting for Food and Job programme*, sorghum seeds were provided to farmers (MoFA, 2017). About 1% of the treatment group received seeds from government and no member from control group received seeds from government. The findings suggest that farmers in the study area do not benefit from seed under the government *Planting for Food and Jobs* programme. Irrespective of dorado being improve variety, the results suggest that most farmers saved and replant dorado.

On the perception about the quality of the seeds used, an average of 24% said the seeds they used were excellent and 63% indicated the seeds were very good. Only a small percentage (less than 1%) said the seeds were bad. This finding shows that many farmers do not buy certified seeds. This further support literature on SHF relying on saving seeds from their own harvest than buying cerified seeds despite low yields from farmer saved seeds (Kuivanen *et al.,* 2016; Morris *et al.,* 2019; Sheahan & Barrett, 2017).

Contrary to views of low fertilizer application among SHF, this study found an average of 65% of the respondents applying fertilizer. About 79% of treatment group and 55% of control group respectively apply fertilizer. The relatively higher fertilizer application among treatment group support literature on input support for farmers on OGS as condition for scheme participation (Maertens & Velde, 2017; MoFA, 2017b; Paglietti & Sabrie Roble, 2012; Ragasa et al., 2018; Takeshima & Lee, 2012).

4.3. Socio-economic and Political Characteristics of the Respondents

Table 4.3 contain results of market, community and socio-economic characteristics of respondents. Nearness to market was used as a proxy to market access. The average distance from home to the nearest market was 1.5 km and 1.2 km for treatment and control groups respectively. Given that more treatment group members were residing relatively far from the nearest market, access to market could be a problem and motivation factor for scheme participation. This finding is similar to other literature on access to market being determinant for the type of crop cultivated by SHF (Ebata & Hernandez, 2017; Opoku, 2012; Villano *et al.*, 2019). About 22% of respondents who belonged to the treatment group hold a form of leadership position in social organisations while 10% of the control group hold leadership positions.

Table 4.3: Market, Community and Socio-economic and Political Characteristics

Variable	Treatment	Control	Overall	Difference (means/freq)	P-value (T-test / Chi-square)
Distance from home to the nearest market (Km)	1.6	0.6	1.1	1.0	0.000***
Farmer holds leadership position (%)	21.8	9.7	15.8	12.1	0.000***
FBO Membership (%)	62.5	0.7	31.6	61.8	0.000***
Access to credit (%)	8.3	2.3	5.3	6.0	0.000***
Extension Visit (%)	54.2	6.7	30.5	47.5	0.000***

, * *and* ****** *denotes significance at 10%, 5% and 1% respectively*

Source: Field Survey data (2018)

On FBO membership, 63% of the respondents from the treatment group belonged to FBO against 1% from the control group. Contrary to Ragasa *et al.* (2018) that FBO membership is not a requirement for participation in outgrower scheme, this results confirmed the argument ISSER (2012); Maertens & Velde (2017) and MoFA (2017) that belonging to a group or FBO increases the chances of participating in new schemes in farming. Ajewole (2010); Mwangi & Kariuki (2015) and Feleke *et al*. (2017) explained that being a member of a farmer association allows information sharing and peer education. Perhaps, during meetings, information on OGS are shared and might have influenced scheme participation.

Access to credit was very low for both treatment and control groups. While 8% of members in the treatment group have access to credit, only 2% of members in the control group have access to credit. This result reinforces the fact that SHF generally faced difficulty in their effort to get credit from financial institutions (Awunyo-Victor & Al-hassan, 2014; Mustapha *et al.,* 2016). Given that access to credit is part of OGS arrangement, access to credit for treatment group was expected to be at least higher than what is reported.

Access to credit attracted a huge debate during FGD discussion in Zari in Garu district. While majority of farmers were disappointed with buyers for not supporting them with credit, there were few farmers who blamed their colleague farmers of failure to honour their part of obligation anytime buyers give them credit. As a farmer put it "*the buyers are not helping us with credit. To farm sorghum well, you need tractor service, fertilizer and money to hire people for weed control and harvesting, but our buyers are not interested in supporting us with money. Any time you ask for support, they will tell you to be managing small-small"*. This was also discounted by another farmer in the group. *"Let us all be sincere to ourselves and tell the truth. I remember in 2016 we were given GHS 500.00 each by Presbyterian-Agricultural station to buy fertilizer, how many of you paid all the money back? For me I paid* *my part and I am still getting support from them. Who will continue to give you money when you failed to honour your obligation?*", he questioned.

On the part of the aggregators, farmers are difficult to deal with and one has to be careful when giving them support. This was a response from an aggregator when questioned about the type of support they give to farmers as part of the OGS arrangement in Jirapa. "*I have been doing this work (sorghum aggregation) since 2010. I worked with different groups of farmers and have learned my lessons. I have given money, fertilizer and weedicide to different groups of farmers in the past but I had it very tough in retrieving my money. Some farmers will even take your inputs and use it to produce for different buyers; will you believe that? Now I only give support to few farmers who demonstrated commitment and sincerity, majority of the farmers we work with are not faithful at all!!, If you are not diligent, they will collapse your business".*

Number of extension visit was used as proxy for access to extension services. The package of extension services discussed with farmers include: training in agronomic practices, early warning system, weather information and planting varieties that are climate resilient. Whereas 54% of members in the treatment group experienced extension visit and training in the above issues in the last farming season, only 7% of members of the control group experienced extension visit. Thus, belonging to outgrowers scheme could influence access to extension services and at the same time, availability of extension services could also be a source of information for scheme participation. Buyers seeking to improve the quality of the sorghum, may organise private extension services or arrange with public extension at the district department of agriculture to train scheme members.

A buyer explains their engagement with farmers on extension provision. *“we are not agronomies, but what we do is to work with the Jirapa District Assembly to allow some of their extension officers to train our farmers. We also pay some allowance for their services, fuelled their motor bikes and provide them with phone credit. The additional information we give them is to teach the farmers on weather information and the type of seeds to plant. Our interest is “dorado” which is early maturing variety so that when the rains stop early, they can still harvest something”.*

During the FGD, a 43-year farmer explained *“the agric officer who come here help me a lot. Last year, he brought some seeds for us to buy. He also told us to plant when the Easter Rain comes” (*Easter rain is the early rain that normally experienced after Easter celebration*). “The seeds take less than three months. When I planted it, in September, it was ready for harvesting. I was able to complete harvesting before the rain stopped in October”.*

Relatively higher extension visit to treatment group support the call for farmers to be in groups for easy extension delivery due to limited number of extension officers (Asfaw *et al.*, 2012; Azumah *et al.*, 2016; Feleke *et al.*, 2017; ISSER, 2012; MoFA, 2017b).

4.4 Description of the Sorghum Outgrower Scheme in the Study Area

This section present results of farmers perception of what explains sorghum outgrower scheme. Major factors of interest presented is the type of contracts between farmers and buyers, how prices are determined and the type of support system received from buyers.

4.4.1 Type of Contracts Between Farmers and Buyers

The results on the type of contracts between farmers and buyers in Figure 4.1 show that 21% of treatment group have documented contract while 79% do not have documented contract with buyers. This result is similar to issues raised during the focus group discussions, that buyers are not interested in signing contracts with farmers, but only interested in the verbal contracts. Several literature on OGS in SSA shows that buyers do not sign formal contract with farmers (Barrett *et al.*, 2012; Fischer & Wollni, 2018; Little & Watts, 1999; Šūmane *et al.*, 2018; Watanabe *et al.*, 2017).

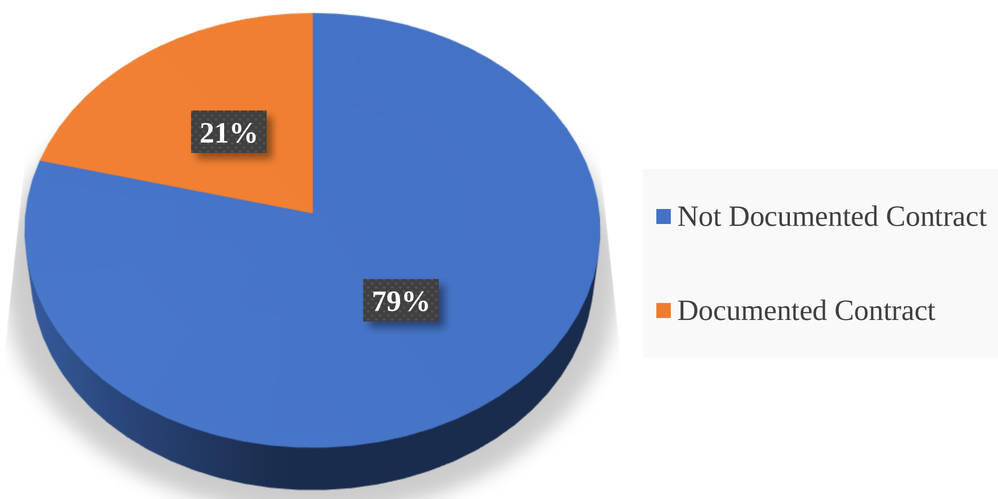

Figure 4.1: Existing Contracts Between Farmers and Buyers

Source: Field Survey data (2018)

4.4.2 Perception of Smallholder Farmers on Price Determination

Figure 4.2 show that 54% of respondents indicated aggregators determining prices while 32% claimed price determination is an arrangement between buyers and farmers. Only 12% said the market determined price while an insignificant number (one person) said farmers determined prices.

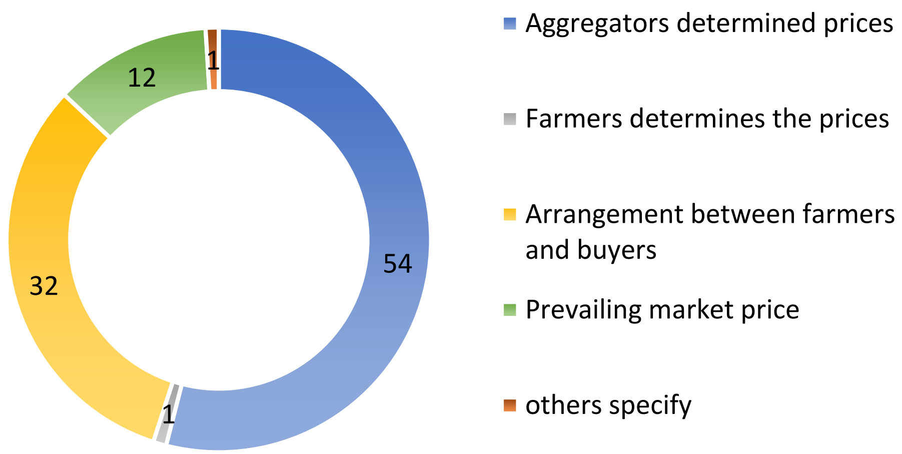

Figure 4.2: Perception of Farmers on How Prices Price Determination

Source: Field Survey data (2018)

The results on price determination support the complains from most farmers during the FGD and individual interviews who claimed aggregators determined prices without consulting them. According to them, they suspect aggregators get attractive prices from GGBL but pay them lower prices. During FGD in Zari, a 37-year male farmer indicated, *"even though the sorghum farming is good, the buyers we work with don't support us with anything. They only come to discuss how to improve on the quality of sorghum we supply to them and the prices they will offer for the season. We don't benefit from the buyers. If we get another buyer, it will* *be good for us"*. Contrary to this accession, the aggregators were also blaming GGBL for not supporting them with inputs, credit and attractive prices. They also expressed fear of non-sustainability of the SOGS due to monopoly power of GGBL and hoped more companies will join the sorghum market and compete with GGBL. These findings support similar reports on buyers imposing prices on farmers in most OGS (Jayne, 2012; Tang *et al.*, 2016).

4.4.3 Kind of Support Received by Farmers from Buyers

The nature of support received by farmers on the SOGS is presented in Table 4.4. This was a multiple-choice question for farmers to list all support received. Among the area of support, 73%, 58% and 54% of the treatment group respectively claimed they received extension services, guaranteed market and fertilizer. Higher percentage of farmers receiving extension services is a reflection on the higher adaptive capacity of treatment group since the training given by Extension Officers included training on weather information, agronomic practices, early warning signs and the need to plant early maturing crop varieties.

Table 4.4: Kind of Support Received by the Sorghum Farmers from Buyers

Kind of support received	Frequency	Percent of cases
Extension Service	76	35.2
Guaranteed market	60	27.8
Fertilizer	56	25.9
Guaranteed price	43	19.9
Seeds	13	6.0
Credit (financial support)	8	3.7
Tarpaulin	2	0.9
Pesticide	1	0.5

Source: Field Survey data (2018)

On access to market, the result suggests that majority of farmers on the SOGS achieved their expectation of market access which was consistently mentioned as a major problem facing farmers.

Access to credit, access to seeds, and tarpaulin recorded low percentages of 6.1%, 13% and 2% respectively. Even though most farmers faced problems with access to credit and expressed their disappointment during the FGD, high default rate, bureaucracies and collateral requirements of financial institutions may be the reason for buyers not supporting farmers with inputs (Alobo, 2019; Al-hassan *et al.,* 2014; Gitonga *et al.,* 2013; Mustapha *et al.,* 2016; Opoku, 2012; Ton *et al.,* 2016; Uaiene *et al.,* 2009)

4.4.4 Specific Support Targeting Smallholder Farmers Vulnerability to Climate Change

Table 4.5 contain results of support that target at capacity building of SHF to withstand climate change. Multi choice questions were directed to both treatment and control groups. The results suggest that both groups received some form of training or support on climate resilient.

For the treatment group the common support received by majority of farmers were information on planting early maturing plant varieties of 51%, planting period 46% and information on harvesting on time 47%. The kind of support received by the control group was information on when to harvest 29%, information on planting early maturing plant varieties 27% and information to engage in off-farm activities 25%. The results is consistent with literature on the role of OGS in modernising the activities of SHF by introducing them to new planting materials and agronomic information (Murphy, 2012; World Bank, 2003).

Table 4.5: Kind of Support on Climate Resilient Received by Farmers

Type of Support/Training	Treatment=216		Control=300		Overall=516	
	Frequency	%	Frequency	%	Frequency	%
Early Maturing Variety	111	51.39	80	26.67	95.5	18.51
Change the Crop Type Cultivated	50	23.15	10	3.33	30	5.81
Change from Crops to Livestock	2	1	8	2.67	5	1
Combine Crop with Livestock	90	40.17	50	16.67	70	13.57
Information on Planting Period	100	46.3	90	30	65	12.6
Information on Harvest Period	100	46.6	86	28.67	93	18.02
Engage Off-farm Activities	30	13.89	74	24.67	52	10.8
Others	6	2.78	60	20	33	6.4

Source: Field Survey data (2018)

This result suggest that the treatment group are likely to be aware of the type of farming practices that makes them less resilient to climate change than those on the control group. *Dorado* being sorghum variety promoted by GGBL and also being early maturing plant variety could be the reason for more treatment group having information on early maturing plant varieties.

During the FGD, majority of farmers on the treatment group indicated their desire to plant the *dorado* sorghum variety due to its early maturing characteristics and its ability to withstand draught and high temperature. They further explained that GGBL advised them to plant the *dorado* between the middle of May to 20th of June. According to them, for other crops, they usually could plant until the end of July and due to short duration of the rainfall, most crops do not mature before the rain stops. This is what 50-year old male farmer indicated: *"we normally plant dorado in late part of May or early June and harvest in September. Unlike other crops, you are able to harvest dorado before the rain stops. Also, if you do not harvest it early and* *the rain fall on it, creamy colour turned to black and you are likely not to get good market for such produce".*

4.5 Factors influencing Smallholder Farmers Participation in Sorghum Outgrower Scheme

Probit regression results of factors influencing SHF participation in the SOGS are presented in Table 4.6. The Prob > chi2 implies that the model is statistically significant and can be used for the estimation. Out of the 15 explanatory variables examined, four variables lacked significant explanatory power. All the other 11 variables were statistically significant with 8 variables having the prior expected sign.

Gender of the farmer is a significant factor influencing participation with probability of a male farmer joining the SOGS increased by 11%. This finding on gender is consistent with Ali *et al. (*2016); Lambrecht (2016); Mariano *et al.* (2012) and Abdul-Razak & Kruse (2017) studies indicating that male farmers have better access to economic resources such as land, credit and technological resources such as better information on the soil fertility which place them in better position to adopt new intervention. The results were expected and is consistent with findings by FAO (2015) and Tanellari *et al.*, (2011) that, male farmers are more likely to adopt contract farming due to functional command over land for scheme participation. Lambrecht (2016) study found similar results that men unlike women have decision making powers over how family land is used in patriarchal societies such as northern Ghana.

Table 4.6: Factors Influencing Participation in the Sorghum Outgrower Scheme

Variable	dy/dx	Std. Err.
Gender (Male=1)	0.11***	0.04
Age of farmer	-0.01***	0.00
FBO Membership	0.50***	0.05
Number of Extension visits received	0.10***	0.02
Distance from community to main market	0.01**	0.04
Marital Status	-0.06	0.04
Household Status	-0.08*	0.04
Formal education completed		
Basic	-0.04	0.04
Higher than Basic	0.08	0.06
Household size	-0.01**	0.01
Main Occupation	0.03	0.05
Farming Experience	-0.01***	0.00
Length of Stay in the community	0.00***	0.00
Farm Size	0.07***	0.02
Access to Credit	0.10	0.07
Leadership in social organization	0.07*	0.04
Number of obs = 516		
Prob > chi2 = 0.0000		
Pseudo R2 = 0.5482		

, * and ******* denotes significance at 10%, 5% and 1% respectively

Source: Field Survey data (2018)

Contrary, Bellemare & Bloem (2018) found gender variable in adoption to be negligible. Their study argued that most household decisions in farm operations such as seed selection are jointly taken by husbands and wife in most rural areas. Since having access to farm land is prerequisite for participation in SOGS participation is likely to skew in favour of male farmers in Northern Ghana.

The probability of participation decreases by 1% for a unit increase in both age and experience. Age of the farmer and farming experience have positive relationship. The older farmers are generally found to be more endowed with experience in farming. Compared to younger farmers, older farmers approached their farming activities as a way of life, content with the little harvest they obtained and are less likely to change from their farming practices to join new intervention (Ajewole, 2010; Udimal *et al.,* 2017). The relatively younger farmers on the other hand appears to be less experienced and will adopt farming practice that generates more income (Al-Hassan *et al.*, 2013). Given the high level of unemployment in Ghana and the fact that sorghum provides ready market relatively younger farmers participating was expected. This is positive development for the study area in the light of high rural urban migration in search of non-existing jobs in southern Ghana.

The household status was included to explain the relationship between being the household head and probability of participating in SOGS. This variable seemed to play important role in the decision to participate with probability of participation decreased by 8% for a unit increase in being the household head. The status of household head in northern Ghana is generally characterised with old age, more responsibilities and more experience in farming (Mustapha *et al.,* 2016; Nkegbe *et al.,* 2017). The results were expected due to the cultural dynamics that obligates the household head to provide food for the family. Hence, household heads will rather cultivate staple food crops for family consumption than sorghum, which has become cash crop in the study area.

Another unanticipated outcome is the probability of participation and household size. While several studies such as Mignouna *et al.* (2011); Ajewole (2010) and Udimal *et al.* (2017) postulate positive relationship between household size and OGS due to availability of family labour to meet labour requirement of OGS conditions, this study found the probability of participation decreased by 1% for a unit increase in household size. Even though the finding may not be similar to what would have happened in other jurisdiction, the results is still relevant and portrays the reality of limited lands for individual members in large families in northern Ghana. Perhaps, large family size could be associated with smaller per unit land size for each member of the family. Apparently, the requirement of separate plots for sorghum production could limit farmers from larger families to participate due to computing uses of the small piece of land for the family food crops production.

Farm size was measured by the number of hectares cultivated in 2017 farming season. The probability of participation increased by 7% for a unit increase in farm size. Farm size is often used as a proxy indicator of wealth and social status in rural communities (Aniah *et al.,* 2019). The positive relationship found between land access and participation in SOGS could be explained by the fact that such farmers have sufficient land for both staple and cash crops production. This finding validates similar observations by Ton *et al., (*2016). In addition, large farm size is an indication of wealth and available collateral to access finance (Ragasa *et al.*, 2018; Ton *et al.,* 2016).

Farmer Based Organisation (FBO) membership play important role in technology adoption and for that matter, participation in SOGS (Maertens & Velde, 2017). Apart from 63% of the treatment group belonging to FBOs, the probability of participation increases by 50% for a unit increase in FBO membership. This findings also confirmed Barrett *et al. (*2012); Feleke *et al.* (2017) and MoFA (2017a) studies recommending farmers to form groups for easy information dissemination, access to credit, access to extension services and easy targeting by government. Working in groups also helped in price negotiation and marketing. To adopt new intervention sometimes is hampered not only by the inherent requirements that might restrict participation but also, lack of information on the benefits of such interventions. Belonging to FBO is a form of social capital that gives information to the farmer (Odunze *et al.,* 2015). Also most agribusiness investors, government and NGOs prefer dealing with farmers in groups than individual farmers (MoFA, 2015, 2017b).

The probability of participation increases by 10% for a unit increase in extension visit. According to Udimal *et al.* (2017), agricultural extension is a learning system that builds human capital of farmers by providing them information and exposing them to improved technologies. This leads to higher profitability and welfare gains. Essentially, farmers with frequent extension visits tend to be more progressive in terms of productivity and profitability (Mwangi & Kariuki, 2015; Udimal *et al.,* 2017). The role of extension agents was frequently mentioned during the FGD and re-emphasised by aggregators and GGBL during the qualitative interviews. As an aggregator indicated in Jirapa *"extension agents popularised the scheme by providing essential information, appropriate knowledge and capacity development in sorghum production. They provide training on quality requirement and standards, marketing and also equipped farmers with information for price negotiation".*

Distance to the nearest market was used as a proxy for access to market. The decision to participate in SOGS has positive relationship with distance to the nearest market. The probability of participating increases by 1% for a unit increase in distance to the nearest market. Information generated during focus group discussion support this claim as the farmers staying far from market complained about distance to the nearest market and low interest of buyers to travel longer distance to buy sorghum. As a 53-year farmer indicated in Sabule "*our roads here are bad, the market is far and getting a vehicle to convey your produce to the nearest market is difficult. But if you manage to send your produce to Jirapa or Wa, they will buy them. We are suffering with how to sell our produce in this community*".

Leadership in social organisation has positive relationship with participation. The probability of participation increases by 7% for a unit increase in leadership position. This was expected since the entry point in rural community starts either with the Chief, Assembly Member, Chief Iman or the Community Pastor. These leaders sometimes participate in selection of beneficiaries of new interventions (Ton *et al.,* 2015). Likelihood of participation of a community leader is higher than those without leadership position.

4.6. Determining the Effects of Outgrower Scheme on Smallholder Farmers Productivity

4.6.1 Productivity Analysis

Table 4.7 contain results of sorghum productivity. Yield per hectare is used to explain sorghum yield in 2017 farming season. On average the treatment group obtained yield of 1,207kg/ha while control group obtained 820kg/ha. The higher yield for treatment group could be attributed to application of quality inputs and good agronomic practice being encouraged by SOGS. The treatment group invest more in hired labour, ploughing; weed control and application of pesticides. Good agronomic practices by treatment group is reflected in their higher expenditure in chemical fertilizer, organic fertilizer, improved seeds, pesticides, cost of hired labour and cost of transportation compared with expenditure by control group. While treatment group spent GHS 355.00, GHS 62.00 and GHS 11.00 respectively on chemical fertilizer, organic fertilizer and pesticides respectively, the control group spent GHS 280.00, GHS 3.00 and GHS 9.00 respectively on the same inputs.

Table 4.7: Comparison of Productivity, Revenue and Costs Across Treatment and Control Groups

Variable	Treatment N= 216	Control N= 300	Overall N= 516	Difference	T-test
Yield/productivity (Kg/Ha)	1206.9	819.86	1013.4	387.03	0.00***
Average Price GHS/Kg	1.2	1.3	1.3	0.1	0.00***
Revenue (GHS/Ha)	1444.4	1027.9	1236.2	416.5	0.00***
Less Variable Cost					
Seed cost (GHS/Ha)	18.8	7.3	13.1	11.5	0.00***
Chemical Fertiliser cost (GHS/Ha)	354.5	280.1	317.3	74.3	0.05*
Organic Fertiliser cost (GHS/Ha)	61.5	2.6	32.1	58.9	0.00***
Pesticide cost (GHS/Ha)	10.7	9.4	10.1	1.3	0.84
Hired labor cost (GHS/Ha)	406.2	218.3	312.3	187.8	0.00***
Family labor cost (GHS/Ha)	305.1	595.9	450.5	290.7	0.00***
Transportation Cost (GHS/Ha)	17.2	6.5	11.9	10.7	0.00***
Total Variable Cost (GHS/Ha)	1174.1	1120.3	1147.2	53.8	0.40**
Profit (excluding family labor) (GHS/Ha)	575.4	503.5	539.5	71.9	0.38
Profit (including family labor) (GHS/Ha)	270.2	-92.4	88.9	362.7	0.00***

, * and ******* denotes significance at 10%, 5% and 1% respectively
Source**:** Field Survey data (2018)

Treatment group spent GHS 406.00 on hired labour while control group spent GHS 218.00 on hired labour. Hired labour cost in this study comprises of cost incurred in ploughing, clearing, gathering and heaping, weeding, harvesting, pesticide application, threshing and winnowing. It appears control group depend more on family/communal labour than scheme members. The control group spent GHS 596.00 on family/communal labour against GHS 305.00 for scheme members. The transportation cost for scheme and control group was GHS 17.00 and GHS 7.00 respectively.

4.6.2 Average Treatment Effect on Sorghum Productivity

The estimation of average treatment effect of SOGS on productivity using ESR are presented in three folds. The results of the FIML in table 4.8, ESR results of treatment effects in table 4.9 and the PSM robustness check results in table 4.10.

The Results of FIML: The results of FIML of the ESR that control for unobservable selection bias and the significance of the ESR results are reported in Table 4.8. The second and fourth column in the table contain the treatment and control equations respectively. To analyse the correlation between decision to participate in SOGS and productivity, a set of broad explanatory variables were included to determine their significance.

Gender, household size, farming experience and FBO members are all statistically significant variables influencing participation decision and at the same time influencing productivity of the treatment group. While the probability of participation decreases with farming experience, the probability of participation increased for being a member of FBO. The positive sign of FBO membership suggests that, being a member of FBO influence participation decision. The result is consistent with earlier results and empirical literature of belonging to FBO influencing participation in OGS (Feleke *et al.*, 2017). The only significant variable on the control equation is farm size. The positive sign suggests that farmers with large farm size who are in the control group are more likely to participate in the SOGS. This result is consistent with earlier results and existing literature that farmers with large farm size are more likely to participate in OGS. Implying that the OGS is not pro-poor farming scheme.

Table 4.8: Results of Full Information Maximum Likelihood Estimates of Endogenous Switching Regression on Productivity

Independent Variable	Outgrowers		Non Outgrowers	
	Coef.	Std. Err.	Coef.	Std. Err.
Gender	173.917*	104.830	7.200	148.689
Age	-0.162	3.362	4.918	4.155
HHstatus	-105.538	126.843	141.759	182.970
Household Size	34.384**	17.015	27.510	20.775
Educated	135.735	99.531	63.474	149.575
Occupation	-90.430	136.051	123.153	200.429
Farming Experience	-28.893**	13.734	-12.139	7.489
Farm Size	209.144***	56.782	456.876***	132.082
FBO Membership	745.623***	157.366	81.828	792.757
Access to Credit	25.958	159.429	-139.127	407.877
Number of Extension Visits received	-5.660	29.647	-58.372	138.510
Constant	736.055**	244.611	646.683**	312.240
/lns	6.448***	0.062	6.918***	0.042
/r	0.960**	0.336	0.175	0.123
Sigma	631.561	39.194	1010.299	42.115
Rho	0.744***	0.150	0.173	0.120
Number of observations = 516				
Wald chi2 (11) = 45.46***				
Log likelihood (χ2 (11) = -658.3***				
prob>chi2 = 0.00				

, * and ******* denotes significance at 10%, 5% and 1% respectively

Source: Field Survey data (2018)

The covariance term for productivity of treatment equation is statistically significant at 1%, implying self-selection into SOGS and that the participating in SOGS may not exhibit the same effects on random sorghum farmers, if they choose to participate in the SOGS.

The value of the chi-square statistics of 45.46 is statistically different from zero, suggesting that the independence assumption of participation decision and productivity must be rejected at 1% level justifying the appropriateness of using the ESR to jointly estimate participation decision and sorghum productivity. The likelihood ratio (LR) chi-square ($\chi 2$ (11) = -658.3) is statistically significant at 1% further confirming that the explanatory variables examined in the model jointly influenced the participation decision and sorghum productivity. The prob>chi2 is indication that the model is significant and can be used for the estimation. Finally, the significance and differences in coefficient of correlation between the participation equation and productivity is an illustration of self-selectivity independent variables of treatment and control equation signifies the presence of heterogeneity in the sample.

The Results of ESR: The ESR results on effect of SOGS on productivity are presented in Table 4.9. Cases (a=1206) and (b=820) along the diagonal represent the actual expectations observed for both treatment and control groups respectively. The results suggest that the treatment group obtained higher productivity of 386 than the control group. Cases (c=374) and (d=831.7) represent counterfactual outcomes for the treatment and control groups respectively. This result suggest that had the treatment group decided not to participate, they would have realised less productivity per hectare and had the control group participated they would have realised higher productivity per hectare than their current productivity by 12.2.

Table 4.9: Endogenous Switching Regression (ESR) Results on Productivity

Treatment Status	Decision Stage To participate	Not to participate	Treatment Effect
Treatment group	(a) 1205.81	(c) 374.2	831.6***
Control group	(d) 831.7	(b) 819.5	12.2***
Heterogeneity effects	BH_1= 374.11	BH_2= -445.3	TH= 819.41***

******* denotes significance at 1%

Source: Field Survey data (2018)

The last column of table 4.9 contains treatment effect of SOGS (the difference between the results of actuals and counterfactual outcomes). The treatment effect is positive for both the treatment group and the control group. This result implies that SOGS has positive effect on sorghum productivity for both the treatment and the control groups.

To gain further understandings of the level of effect, the heterogeneity effect is reported in the last row of the Table 4.9. The heterogeneity effects for treatment (BH_1) = 374.11 and control (BH_2) = -445.3. The differences in BH_1 and BH_2 illustrate existence of unobserved heterogeneity effects. The transitional heterogeneity effect (TH) is positive and significant at 1%. This suggest that SOGS has effect on both treatment and control groups. In conclusion, the SOGS has positive effect on random sorghum farmer who choose to participate in the OGS in the study area. The level of effect is not mainly due to participation in the SOGS but there exist unobserved characteristics of the treatment group that influenced their participation decision and their productivity.

The Results of PSM: The PSM estimates is used for robustness check. The distribution of propensity scores, indicator of matching quality, sensitivity analysis and quality test of matching algorithm are attached in Appendix 4 Figure A1, Table A7, Table A8 and Table A9 respectively. The nearest neighbour matching results on common support generated was 383. This shows that 133 respondents lack similarity in terms of their observable characteristics. The PSM results suggest significant reduction in differences in observable characteristics of the treatment and control group after matching and that there are no significant differences in observed characteristics between the treatment and control groups under PSM estimation.

The PSM results of the average treatment effect on the treated (ATT) and the untreated (ATU) are presented in Table 4.10. The ATT and ATU results in Table 4.10 are 858 and 348 respectively. The results further confirmed positive effect of SOGS on productivity. Comparing the treatment effect of ESR of 831.6 and 12.2 for the treatment and the control groups respectively with the PSM results of 858 and 348, it appears PSM overestimated the effect on both the treatment and control groups. The differences could be due to existence of unobserved characteristics that PSM could not addressed (Donkor & Owusu, 2019). The ESR results and the PSM results is consistent with empirical literature on positive effect of OGS on SHF productivity (Maertens & Velde, 2017; Ragasa *et al.*, 2018).

Table 4.10: Propensity Score Matching Results on Farm Productivity

Sample	Effect	Std. Err	T-stat
ATT	858.0***	138.0	4.8
ATU	348.0***	130.4	2.7
ATE	454.6***	110.3	4.1

******* denotes significance at 1%

Source**:** Field Survey data (2018)

4.7 Determining the Effects of Outgrower Scheme on Smallholder Farmers Profitability

4.7.1 Profitability Analysis

Table 4.7 above contain results of SHF profitability. The average profit received by treatment group was GHS 575.00/ha and that of the control group was GHS 504.00/ha. When family labour is computed as part of variable cost of which control group largely rely on but do not cost it, the treatment group profit reduces to GHS 290.00/ha while the control group incurred loss of GHS -92.00/ha.

Even though the treatment group incurred high variables cost of GHS 1,174.00/ha, they still got high profit due to higher yields. The higher variable cost for treatment group is due to increase in fertilizer application, improved seeds used and the use of hired labour to ensure proper farm management. In terms of prices received, the treatment group and control group received GHS 1.20/kilo and GHS1.30/kilo respectively. The lower prices received by treatment group is attributed to contractual arrangement that pre-determined prices before production begins. Also, clauses in contractual agreement usually prevents treatment group from selling to open market irrespective of open market prices (Odunze *et al.,* 2015). The flexibility of control group to be able to store and sell their produce during lean season may account for their higher prices relative to the treatment group.

4.7.2 Average Treatment effects on Profitability

The Results of FIML: The results of FIML on profitability are presented in Table 4.11. Gender and FBO membership in the treatment equation are significant with positive signs. This suggest that male farmers and a member of FBO influenced the treatment group participation in the SOGS and their profitability. The finding confirmed earlier report and consistent with existing literature on positive relationship between male farmers and FBO membership on participating in OGS (Feleke *et al.,* 2017). Access to extension services has negative sign and significant at 5% suggesting that extension services has influence on the treatment group members participation in the SOGS. This implies that the treatment group who participated will not have participated if they were to have access to extension services suggesting that expectation of getting extension services when join OGS is a significant factor influencing participation. For the control equation, age, being the head of household, having farming experience and access to credit are significant factors influencing participation. Whiles age, being household head and having more farming experience influence participation positively, access to credit has negative influence.

Table 4.11: Full Information Maximum Likelihood Estimates Results on Profitability.

	FIML Endogenous Switching regression model			
	Outgrowers		Non Outgrowers	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
Gender	300.52*	148.07	-129.12	132.80
Age	4.67	4.71	-7.34**	3.71
HH Status	26.32	179.18	-277.18*	163.63
Household size	-3.16	23.76	28.95	18.69
Educated	104.55	138.90	119.81	133.65
Occupation	-43.21	191.96	94.07	179.02
Farming Experience	-6.90	19.79	-15.61*	6.97
Farm Size	-56.94	77.75	194.29	119.68
FBO Membership	411.60**	193.19	-890.09	754.03
Access to Credit	147.35	217.87	-822.93*	365.01
Number of extension visits received	-85.72**	39.82	100.96	125.89
Constant	-258.38	338.17	-847.82***	282.32
/lns1	6.73	0.05	6.80	0.04
/r1	0.05	0.18	0.07	0.19
sigma_1	839.35	40.44		900.68
rho_1	0.05*	0.18		0.07
Number of obs = 516				
Log likelihood = 1433.48***				
Wald chi2(11) = -19.66***				
Prob > chi2 = 0.05				

, * and ******* denotes significance at 10%, 5% and 1% respectively
Source: Field Survey data (2018)

Also, the chi-square statistics of 19.66 is statistically significant and different from zero, meaning that the independence assumption given to the selection and the outcome equations must be rejected at 1% level. The likelihood ratio (LR) chi-square ($\chi2$ (11) = -1433.48) is statistically significant at 1% further confirming that the explanatory variables examined in the model jointly influenced the participation decision and sorghum profitability. The prob>chi2 is indication that the model is significant and can be used for the estimation. Finally, the significance and differences in coefficient of correlation between the participation equation and profitability is an illustration of self-selectivity and presence of heterogeneity in the sample.

The Results of ESR: The ESR results of treatment effect of SOGS on profitability under actual and counterfactual conditions for treatment and control groups are presented in table 4.12. Cells (a=270.3) and cell (b=-92.5) represent the expected profitability observed. The results suggest that the expected profitability of the treatment group is higher than the control group. The counterfactual outcomes suggest that, had the treatment group decided not to participate, they would have realized losses of GHS 482.10/ha and had the control group decided to participate, they would have made profit of GHS 42.70 against their current losses of GHS 92.50/ha.

Table 4.12: Endogenous Switching Regression Results on Profitability

Farm Profitability (GHS/Ha)	Decision Stage To Participate	Not to participate	Treatment Effect
Treatment group (ATT)	(a) 270.3	(c) -482.1	752.4^{***}
Control group (ATU)	(d) 42.7	(b) -92.5	135.2^{***}
Heterogeneity effects	BH_1= 227.6	BH_2= = -389.6	TH= 617.2^{***}

******* denotes significance at 1%

Source: Survey data (2018)

The last column of the table 4.12 contain treatment effect on profitability. The results show positive effect on both treatment and control group with the effect being higher for the treatment group than the control group.

The last row contains heterogeneity effects with BH_1 =227.6 and BH_2= -389.6 respectively. The higher value for BH_1 shows that SOGS has more effect on the treatment group than the control group. The differences in $BH_1$and BH_2 illustrate existence of unobserved characteristics that influence profitability apart from the SOGS. The transitional heterogeneity effect (TH) is positive effect of SOGS on profitability on both treatment and control groups.

The Results of PSM: The PSM results presented in Table 4.13 show ATT and ATU results as 1159 and 352 respectively. This means that the SOGS has positive effect on profitability for both treatment and control group which is consistent with the ESR results except that the effect under PSM is higher than ESR indicating overestimation of treatment effects under PSM. The differences in the results may be attributed to inability of the PSM to account for unobservable factors.

Table 4.13: Propensity Score Matching Results on Profitability

Sample	Effect	Std. Err	T-stat
ATT	1159.3^{**}	770.1	1.5
ATU	351.5^{***}	159.6	2.2
ATE	629.2^{**}	425.3	1.5

** and ******* denotes significance at 5% and 10% respectively**.**
Source: Survey data, (2018)

4.8 Determining the effects Outgrower Scheme on Smallholder Farmers Postharvest Loss Reduction

4.8.1: Analysis of Postharvest Situation in the Study Area

Table 4.14 contains results of postharvest loss among treatment and control groups. The average postharvest loss for treatment and control groups are 14.2% and 27.4% and the value loss of GHS 193.00/ha and GHS 166.00/ha for the treatment and control groups respectively. The higher value loss of the treatment group is due to high quantity harvest of which small percentage loss represent high value of total harvest.

Figure 4.3 contain percentage losses in the various postharvest stages. The highest losses for treatment group is recorded during storage of 4.4%, grading and bagging 3.8% and transporting from homestead to market 2.8%.

Table 4.14: Postharvest Loss for Treatment and Control Groups

Variable	Treatment N= 216	Control N= 300	Overall N= 516	Difference	T-test
Loss during transportation from farm to homestead (Kg)	17.2	12.6	14.9	4.6	0.349
Losses during heaping	9.1	10.5	9.8	1.4	0.446
Losses during threshing and winnowing	11.1	9.5	10.3	1.6	0.349
Losses during grading and Bagging (Kg)	42.8	11.9	27.4	30.9	0.082
Losses during Storage (Kg)	49.5	64	56.8	14.5	0.004
Losses during transportation from homestead to the market (Kg)	31.3	18.9	25.1	12.4	0.147
Average Quantity lost (Kg)	161	127.4	144.2	33.6	0.849
Average value of Losses (GHS)	193.2	165.6	179.4	27.6	0.918
Total quantity harvested that is lost (%)	14.2	27.2	20.7	13.0	0.150
Average Quantity Harvested (Kg)	1130.8	468.1	799.5	662.7	0.000
Average Price (GHS/Kg)	1.2	1.3	1.3	0.1	0.000
Value of Quantity harvested (GHS)	1356.0	608.5	982.3	747.5	0.000

Source: Field Survey data (2018)

For the control group, the highest losses were recorded during storage of 13.7%, transporting from homestead to the market of 4% and transporting from farm to homestead of 2.7%. The high storage loss for both groups was expected and is consistent with studies by Gitonga *et al.*, (2013) and Hengsdijk (2017) of which limited warehouses and lack of storage facilities to protect grains from moisture, pest and insect's infestation led to high postharvest loss among SHF in SSA. Also, the relatively low storage loss of treatment group compared to control group could be attributed to guaranteed market by SOGS for treatment group leading to shorter duration of storage period compared to control group who normally stored produce in anticipation of good prices during lean season.

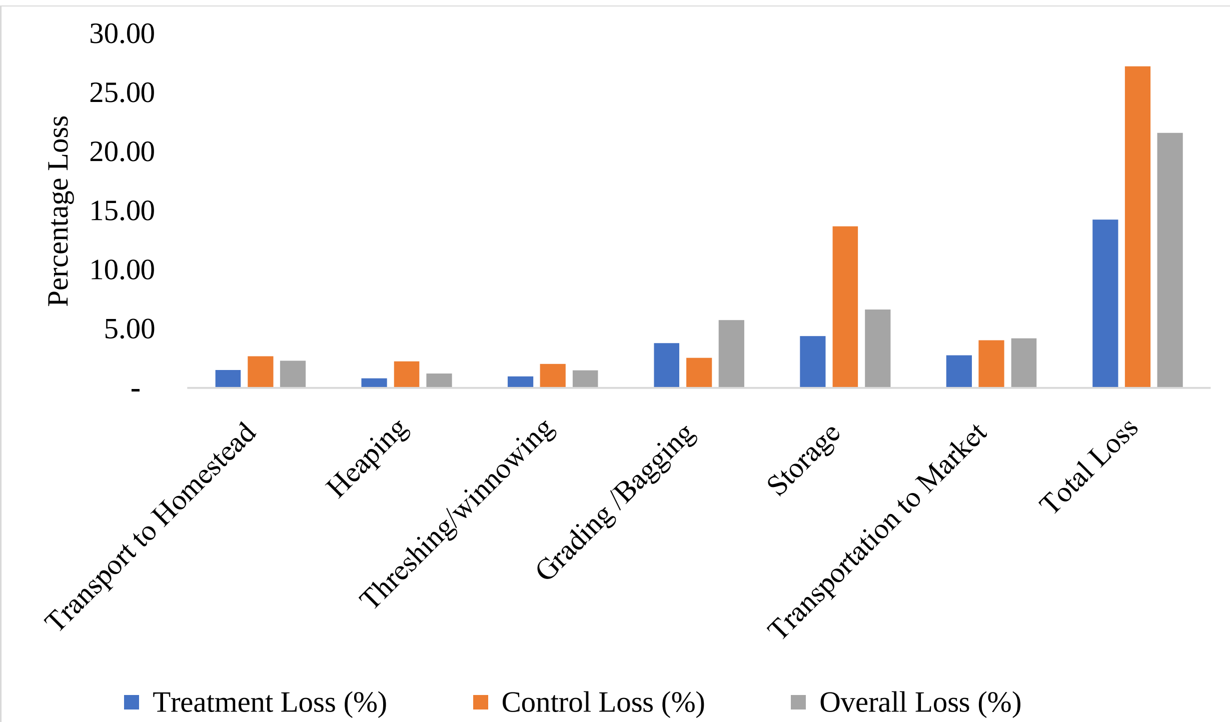

Figure 4.3: Percentage Losses in the Various Postharvest Loss stages

Source: Field Survey data (2018)

The need for appropriate storage facilities were emphasised during the focus group discussion in both treatment and control communities. According to a 47-year female farmer in Gozeig community in Garu, "*I remember in 2015, after I harvested my sorghum in September, it rained consistently for three days. I left the un-threshed sorghum on the rain because there was no place to store them. By the time I started the threshing in somewhere January, about half of the sorghum went bad and the colour also changed to black. You won't believe that Faranaya (company that buy sorghum for GGBL in Garu) rejected them when it was time for buying, claiming that GGBL will not accept this type of sorghum?"*.

In Kuncheni community in Jirapa, a 59-year-old male farmer also narrated how he lost his sorghum grains to rats and mice. According to him, "*After harvesting, I stored my sorghum grains in a room I converted into a store room whiles waiting for good price to sell. One day I entered the room to check whether the sorghum was in good condition. To my surprise, I rather provided good feeding grounds for rats and Mice. Most of the bags were leaking and the grains were spread everywhere in the room. Some of the bags reduced in size after we removed them*". The situation of postharvest loss in Ghana is serious and is acknowledged by the government in the 2018 national budget of which budget allocation was made for construction of at least, one warehouse in every district to help address storage challenges facing farmers (Ministry of Finance, 2018). The high grading/bagging loss of 3.8% for treatment group was however not expected and its occurrence could be due to repackaging requirement by buyers.

Another result is losses that occurred during transportation. Losses of 2.7% and 1.5% respectively is reported for transporting produce from homestead to market centre and farm to homestead respectively for treatment group. Similar results of 4.0% and 2.7% were reported for control group on transporting from homestead to market and from farm to homestead. The high losses recorded during transportation could be due to poor feeder roads in the study area which was expressed during the FGD. Some farmers claimed they sometimes produced for birds and rodents due to their inability to transport the produce to the nearest storage centres immediately after harvest.

In appendix 3, results of causes of sorghum losses in the various postharvest loss stages are presented. Both treatment and control group reported poor road networks, lack of appropriate vehicles and long distance from farm to storage centres of 69%, 62% and 57% respectively as major causes of postharvest losses during transportation. This result is similar to information provided during the expert interviews and FGD of which poor feeders roads was consistently mentioned as a major constraint to sorghum production in the study area. Also several literature such as Affognon *et al.*, (2015); FAO (2014b) and Rembold *et el.* (2014) all cited poor feeder roads and lack of appropriate vehicles in most rural areas as a major cause of postharvest loss in SSA. Also, the highest causes of storage losses for both treatment and control groups are high rainfall, aflatoxin contamination and insects attack of 12%, 5.2% and 7.6% respectively (appendix 3, table A6).

4.8.2 Average Treatment Effects of Sorghum Outgrower Scheme on Postharvest Loss Reduction

Results of FIML: The results of FIML estimate on postharvest loss reduction are reported in Table 4.15. The second and fourth column in the table contain the treatment and control equations respectively. To analyse the correlation between decision to participate in SOGS and postharvest loss reduction, a set of broad explanatory variables were included in the model to establish their influence in participation decision and postharvest loss reduction.

Age of the household head, age of the farmer and access to extension services have negative sign and are statistically significant variables influencing participation decision and postharvest loss reduction for the treatment group. The result is inconsistent with earlier results of older farmers; being household head and farmers who have access to extension services less likely to participate in new intervention. Belonging to FBO influencing participation in SOGS is also consistent with earlier results and empirical literature on FBO members likely to adopt new technology compared to those who are not. For the control equation, the household head, household size and access to extension services are statistically significant factors influencing participation decision. The negative signs are indications that the household head, household size and access to extension services negatively influence participation and postharvest loss reduction.

Table 4.15: Full Information Maximum Likelihood Estimates Results on Postharvest Loss Reduction

Dependent variable: SOGS and PHL	FIML Endogenous Switching Regression Model			
	Treatment		Control	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
Gender	0.003**	0.007	-0.007	0.008
Age-Squared	-0.004***	0.000	-0.05	0.000
Age	-0.004***	0.001	-0.001	0.001
HH Status	0.002	0.008	-0.031**	0.010
Household size	-0.0001	0.001	-0.002*	0.001
Educated	0.004	0.006	-0.006	0.008
Occupation	0.010	0.009	0.014	0.011
Farming Experience	-0.0001	0.001	0.001	0.000
Farm Size	0.0001	0.003	0.020*	0.007
FBO Membership	0.013*	0.007	0.068	0.046
Access to Credit	0.008	0.010	0.009	0.023
Number of extension visits received	-0.003*	0.002	0.013*	0.008
Constant	0.107***	0.030	0.075**	0.032
/lns	-3.291*	0.048	-2.888***	0.042
/r	-0.016	0.109	0.117	0.192
Sigma	0.037**	0.002	0.056	0.002
Rho	-0.016	0.108	0.116	0.189

Number of obs = 516
Wald chi2(11) = 27.95***
Log likelihood = 672.76***
Prob > chi2 = 0.001

*, ** and *** denotes significance at 10%, 5% and 1% respectively
Source: Field Survey data (2018)

The likelihood ratio (LR) chi-square ($\chi 2$ (11) = 672.76) suggest that the vector of explanatory variables examined in the models jointly influenced participation decision and its effect on postharvest loss reduction for the treatment and control groups. The chi-square statistics of 27.95 is statistically significant and different from zero meaning that the independence assumption given to the selection and the outcome equations must be rejected at 1% level. The significance of the coefficient of correlation between the participation equation and postharvest loss reduction is an illustration of self-selectivity and presence of heterogeneity in the sample which is controlled during the estimation of the treatment effect.

The Results of ESR: The Table 4.16 contain results of ESR on the effect of SOGS on postharvest loss reduction under actual and counterfactual conditions. The (Cells a=14.24) and (cell b=27.22) represent the expected postharvest loss observed for treatment and control groups respectively. Cell (c=20.4) and (cell d=13.6) presents counterfactual outcome for treatment and control groups respectively. The treatment group had less postharvest loss than the control groups for actual and high postharvest loss than the control under counterfactual condition.

Table 4.16: Endogenous Switching Regression Results on Postharvest Loss Reduction

Crop Loses	Decision Stage To Participate	Not to enrol	Treatment Effect
Treatment	(a)14.24	(c) 20.4	-6.16
Control Group	(d)13.6	(b) 27.22	-13.62
Heterogeneity effects	BH_1= 0.64	BH_2= -6.82	TH= 7.46

Source: Field Survey data (2018)

The last column of the Table contains average treatment effect. The results suggest that, the treatment effect on the treatment and the untreated are -6.16 and -13.62. The results suggest that sorghum farmers who did not participate in the SOGS, if they had participated, they would have realised lower average sorghum postharvest loss than treatment group who participated. Also, had the treatment group decided not to participate, they would have realised low postharvest loss than control group Case (c) but higher than their current postharvest loss. This result suggests that participation in SOGS has positive effect on postharvest loss reduction for both treatment and control groups but the effect is more on the control group than the treatment group. This means that if the control group had participated in the OGS, their postharvest losses would have been lower than the treatment group.

The last row of the Table 4.16 contains heterogeneity effects. The differences in the values of BH_1 and BH_2 of 0.64 and -6.82 respectively suggest that the effects of SOGS is higher on control group than the treatment group. The differences in the BH_1 and BH_2 illustrates existence of some unobserved heterogeneity effects (for example farming skills of individual households in managing postharvest losses) that makes control group better in controlling postharvest loss than treatment group if control group had participated in the SOGS. Finally, the positive value of transitional heterogeneity (TH) effect suggests that SOGS has positive effect on both treatment and control group.

The Results of PSM: The PSM results presented in Table 4.17 show ATT and ATU as -0.07 and -0.01 respectively. The result is consistent with ESR results of SOGS having effect on postharvest loss reduction for both treatment and control groups. Unlike the ERS results, the effect on loss reduction is higher under PSM estimate. The differences in effect under ESR and PSM could be attributed to inability of PSM to account for unobservable factors and therefore over estimation the effect.

Table 4.17: Propensity Score Matching Results on Postharvest Loss Reduction

	Effect	Std. Err	T-stat
ATT	-0.8***	0.04	-8.7
ATU	-0.14***	0.03	0.5
ATE	-0.16	0.03	-0.6

*** denotes significance at 1%
Source: Field Survey data (2018)

4.9 Determining the Vulnerability Level of Smallholder Farmers to Climate Change

This section present results of SHF vulnerability to climate change. The results are in two folds. The first fold contains LVI and LVI-IPCC results of the state of vulnerability of SHF to climate change among treatment and control groups. The second part present results of treatment effect of SOGS in reducing the vulnerability of SHF to climate change.

4.9.1 Results of Vulnerability of Smallholder Farmers to Climate Change

Results of Major and Sub-component: Table 4.18 contain indices on sub and major components for treatment and control groups. The corresponding percentages are found in appendix 5 table A10. The vulnerability indices of the major component ranges from 0.228-0.524. Indices closer to 0.228 suggest less vulnerable to climate change and indices closer to 0.524 indicate high level of vulnerability.

Table 4.18 contain results of water, socio-demographic, food and social network sub and major components. The water major component has relatively lesser vulnerability index of (*LVI=0.401*) for control group than the treatment group of (*LVI=0.417*). The control group recorded 27.67% of households reporting conflicts over water resources compared to the treatment group of 36.28%. In terms of natural water source utilization, the treatment group recorded 86.51% while the control group recorded 74%. This result suggests that, the treatment group is more vulnerable in access to quality water as compared to the control group**.** The result is consistent with Adu *et al*. (2017) report that households depending on natural water sources such as lakes and dam are vulnerable to water borne diseases. In terms of consistent water supply, the control group recorded 46.33% and treatment group 59.07%. Due to over reliance on natural water source in both region the households are affected much during the dry season when most natural water sources tend to dry up. The results further suggest that most households in the two regions stored water to be used later.

Table 4.18: Indexed Sub and Major Component of LVI for Water, Socio-demographic, Food and Social Network

Sub-component	Control	Treatment	Major component	Control	Treatment
Percent reporting water conflict	0.28	0.36	Water	0.401	0.417
Percent dependent on natural water sources	0.74	0.87			
Time spend to source water	0.20	0.15			
Percent that have no consistent water supply	0.46	0.59			
Inverse of the average number of liters of water stored per household	0.32	0.11			
Dependency ratio	0.21	0.18	Socio-demographic profile	0.300	0.300
Percent of female-headed households	0.29	0.29			
Percent of households where the head has not attended school	0.94	0.99			
Percent of households with orphans	0.08	0.19			
Percent who dependent solely on family farm for food	0.99	0.99	Food	0.408	0.352
Average number of months strugging to find food	0.44	0.33			
Average crop diversity index	0.21	0.36			
Percent of households that do not save seeds	0.33	0.005			
Percent of households that do not save crops	0.07	0.07			
Average Receive: Give ratio	0.21	0.18	Social Networks	0.478	0.485
Average Borrow: Lend	0.29	0.29			
Percentage that have not gone to their local government for assistance in the past 12 months	0.94	0.99			

Source: Survey data (2018)

Given that SOGS intervention do not focus on providing water as part of the SOGS package, no meaningful correlation could be drawn from scheme participation to impact on water utilization. During focus FGD in Sabule community, a 47-year-old woman expressed her disappointment in the area of support for access to quality water as she narrated her experience: *“the buyers do not care whether we have drinking water or not, their only interest is on sorghum production and supply. Access to quality water is a serious problem in this community, especially during the dry season. Without water, you cannot be strong to farm”.*

In terms of the food major component, the treatment group was found to be more vulnerable (*LVI = 0.352*) than control group (*LVI= 0.348*). The average number of months households struggle to find food was found to be higher (3months) in the control than their treatment counterpart who recorded 4months. This result could be interpreted as farmers using all their food crops lands for producing sorghum leading to domestic food shortage. According to Drafor, Kunze, & Sarpong (2013), increasing food production improves food security outcomes and access to food improves household’s resilience to external stresses including extreme climatic events. This can be inferred that, as individuals, communities and countries improve their food production, there could be reduction in real prices for food which could results in improved real incomes and asset accumulation. This could motivate them to adapt climate change strategy.

On sources of food, the result showed that about 99% of the households in the control depend solely on the family farm for food whereas about 98% of the households in the treatment group depend solely on the family farm for food. The average crop diversity index showed that the treatment group was more vulnerable (*LVI= 0.36*) than the control group (*LVI = 0.22*). This can be explained by the fact that, farmers in the treatment group use most of their lands for growing sorghum and use less for other crops whereas the farmers in the control group do mixed cropping. With sorghum, farmers usually do not intercrop with other crops. An officer from the district Directorate of Agriculture from Jirapa indicated: *“sorghum will do well when it is grown as a mono crop. We advised the farmers not to intercrop sorghum with other crops,* *especially, the dorado and kapala variety*". When all the three sub-components under social network were aggregated, the control group was found to be more vulnerable (*LVI = 0.485*) than the treatment group (*LVI = 0.478*).

Table 4.19 contain results of livelihoods strategies, natural disasters and health. Under the livelihood strategies major component, the control group showed greater vulnerability (LVI= 0.456) than the treatment group (*LVI= 0.393*).

Table 4.19: Indexed Sub and Major Component of LVI for Livelihood Strategy, Natural Disaster and Climate Change and Health

Sub-component	Control	Treatment	Major component	Control	Treatment
Percent households who family members work in different communities	0.19	0.12	Livelihood strategies	0.456	0.393
Households dependent on agriculture as main source of income	0.90	0.70			
Average agricultural livelihood diversification index	0.28	0.36			
Percentage hat do not receive a warning about the pending natural disaster	0.96	0.92	Natural Disaster and climate variability	0.488	0.524
Households experienced injury and death due to natural disaster	0.003	0.005			
Average number of floods, drought, bushfires events in the past 6 years	0.18	0.43			
Mean monthly average minimum daily temperature (years: 1983-2013)	0.55	0.55			
Mean, standard deviation of monthly average maximum daily temperature (years: 1983-2013	0.53	0.53			
Mean, standard deviation of monthly average precipitation (years: 1983-2013)	0.71	0.71			
Average time to health facility by walking	0.13	0.21	Health	0.228	0.242
Households having family member with chronic illness	0.09	0.13			
Households who family member had to miss work or school in the past 6 months	0.38	0.33			
Average malaria exposure prevention index	0.31	0.30			
Overall LVI				0.386	0.393

Source: Survey data (2018)

When all the sub-components under health were aggregated, the control group showed more vulnerability (*LVI= 0.288*) than the treatment group (*LVI=0.242*). control group are less vulnerable in natural disaster and climate change (*LVI = 0.488*) compared to the treatment group (*LVI=0.524*).

From appendix 5 table 10A, about 95% of the households in the control group did not receive warning about pending natural disaster whereas 91% of those in the treatment group did not receive warning about impending disaster. The overall aggregated LVI computed showed that the treatment group was more vulnerable (*LVI=0.393*) in terms of climate change than their control counterpart (*LVI=0.386*).

In table 4.20, the LVI-IPCC was also computed by grouping the seven major components into three categories, namely, exposure, sensitivity and adaptive capacity. The exposure indices were 0.488 and 0.524 for the control and treatment groups respectively. For sensitivity, the indices were 0.332 and 0.344 respectively for control and treatment groups. The results suggest that the treatment group are more vulnerable in the area of exposure and sensitivity than the control group. The index for adaptive capacity was 0.400 and 0.383 for the control and treatment groups respectively. The results suggest that treatment group can adapt to climate change better than the control group.

Table 4.20: LVI-IPCC Contribution Factors to Climate Change

IPCC Contributing Factors to Vulnerability	Control	Treatment
Exposure	0.488	0.524
Adaptive Capacity	0.400	0.383
Sensitivity	0.332	0.344
LVI-IPCC	0.029	0.048

Source: Survey data (2018)

Adaptive capacity is an important variable in determining the impact of climate change on livelihoods of the poor. While sensitivity and exposure are exogenously determined, the adaptive capacity could be enhanced through capacity building, income, assets accumulation, information and knowledge sharing. The treatment group being less vulnerable in adaptive capacity could be associated with the SOGS which provide support to farmers to improve their livelihood outcomes. The work of Aniah *et al.* (2019) on smallholder farmers' livelihood adaptation to climate variability and ecological changes in the savanna agro ecological zone of Ghana confirmed the important role of building the adaptive capacity of SHF farmers as an ideal approach to addressing their vulnerability.

To further confirm contribution factors to vulnerability, IPCC vulnerability exposure, sensitivity and adaptive capacity is presented in the vulnerability triangle as shown in Figure 4.4. It ranges from 0 (low contributing factor) and 0.6 (high contributing factor). The vulnerability triangle further confirmed that the treatment group was more vulnerable to climate change in the area of exposure and sensitivity and less vulnerable in the area of their adaptive capacity.

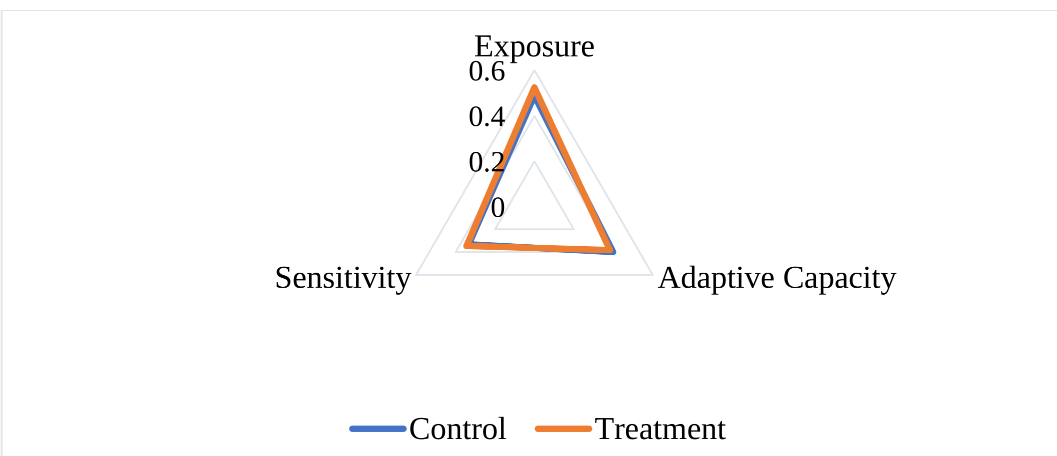

Figure 4.4: Vulnerability Triangle Diagram of LVI-IPCC for Control and Treatment
Source: survey data, (2018)

Finally, all the major components are summarized in vulnerability spider in Figure 4.5. The vulnerability spider diagram ranges between 0 (less vulnerable) and 0.6 (Extremely vulnerable). The control group was more vulnerable in terms of livelihood strategies whereas the treatment group was more vulnerable in terms of natural disaster and climate variability, food, health, water and social network. The two groups obtained the same level of vulnerability in terms of the socio-demographic profile. The overall LVI estimates for the control and treatment groups are 0.386 and 0.393 respectively. This implies that in the overall LVI computed, the treatment group was more vulnerable than the control group.

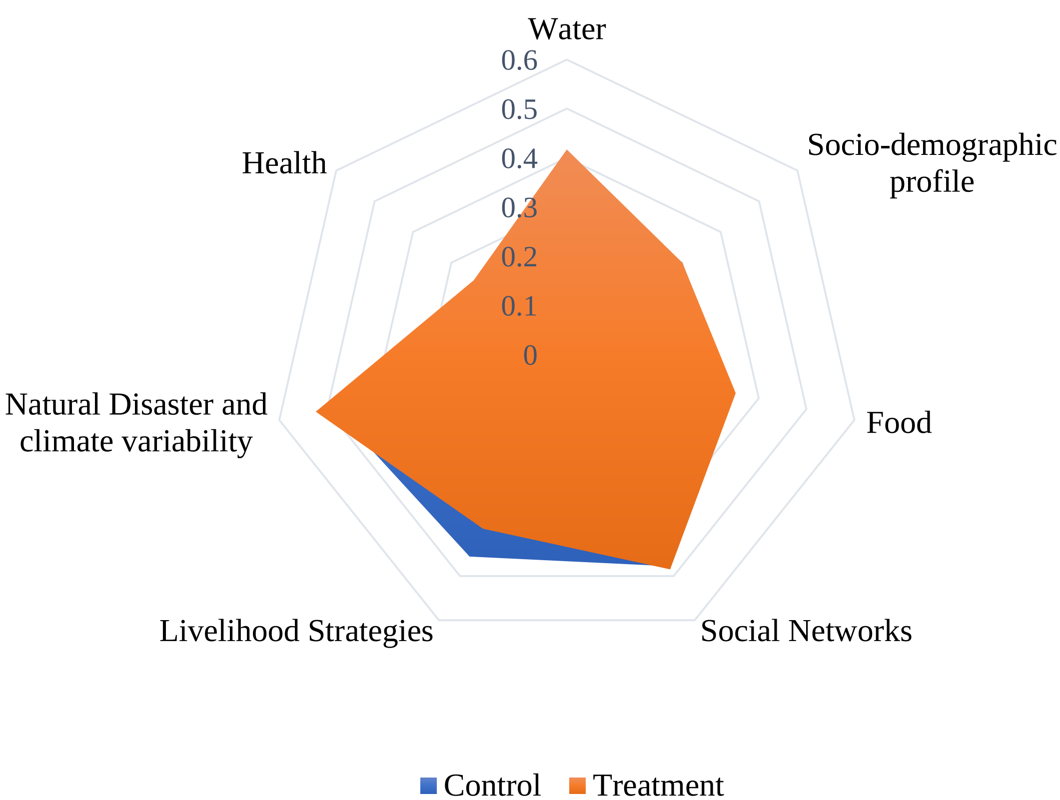

Figure 4.5: Vulnerability Spider Diagram of the Major Components of the LVI for Control and Treatment Groups

Source: Survey data, (2018)

4.9.2 Average Treatment effects on Smallholder Farmers Vulnerability to Climate Change

The results of FILM: The results of FIML of the ESR that control for unobservable selection bias and the significance of the ESR model are reported in Table 4.21. The second and fourth column in the table contain the treatment and control equations of FIML respectively. To analyse the correlation between decision to participate in SOGS and effect of SOGS on reducing SHF vulnerability to climate change, broad set of explanatory variables were included in the model to establish their influence in participation and effect on reducing SHF vulnerability to climate change.

Table 4.21: Full Information Maximum Likelihood Estimates of effects of Sorghum Outgrower Scheme on Reducing Vulnerability to Climate Change

	Treatment group		Control group	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
Gender	-0.001	0.005	0.001	0.0027
Age2	0.007	0.000	-0.000	0.000
Age	-0.001	0.001	0.000	0.000
HH Status	0.002	0.007	0.003	0.003
Household size	-0.002	0.001	-0.000	0.000
Educated	-0.003	0.006	-0.001	0.003
Occupation	-0.002	0.007	0.003	0.004
Farming Experience	0.001	0.001	0.000	0.000
Farm Size	-0.001	0.003	0.005**	0.002
FBO Membership	-0.013*	0.008	0.005	0.016
Access to Credit	-0.029***	0.011	-0.028***	0.007
Number of extension visits received	-0.010***	0.004	-0.002	0.003
Constant	0.035	0.029	0.011	0.010
/lns	-3.602***	0.098	-4.111***	0.046
/r	-0.944***	0.287	0.071	0.347
Sigma	0.027	0.003	0.016	0.001
Rho	-1.474**	0.131	0.071	0.345
Number of obs = 516				
Wald chi2(12) = 19.98***				
Log likelihood = 816.73**				
Prob > chi2 = 0.067				

, * and ******* denotes significance at 10%, 5% and 1% respectively

Source Survey data, (2018)

Apart from FBO membership, access to extension services and access to credit on the treatment equation being significant, the rest of the explanatory variables are not significant and have no influence on participation decision and reduction in vulnerability to climate change. Access to credit is statistically significant at 1% with negative coefficient implying that access to credit influence farmers decision to participate negatively. Otherwise, farmers with access to credit participating in the SOGS are less likely to reduce their vulnerability to climate change.

For the control equation, the only significant variable influencing participation is access to credit at 1% significance with negative coefficient. This implies that farmers in the control group who have access to credit are less likely to participate in the SOGS. The results is consistent with literature on difficulty SHF have in accessing credit and will not be willing to participate in intervention provided they already have access to credit (Uaiene *et al.*, 2009).

The likelihood ratio (LR) chi-square ($\chi 2$ (11) = 816.73) is statistically significant at 5% level. This finding suggests that the explanatory variables in the models jointly influenced participation decision and vulnerability of the treatment and control groups to climate change. The chi-square statistics of 19.98 is statistically significant and different from zero meaning that the independence assumption given to the selection and the outcome equations must be rejected at 1% level.

The Results of ESR: The ESR results on effect of SOGS are presented in table 4.22. Cases (a= 0.393) and (b=0.386) along the diagonal represent the actual expectations observed for both treatment and control group on SHF vulnerability to climate change respectively. This finding suggests that, the treatment group is more vulnerable to climate change than the control group. Cases (c=0.395) and (d=0.376) represent the counterfactual expected outcomes. The counterfactual outcome is lower than the actual outcomes for control group and higher than the actual outcome for the treatment group. this means that if the treatment group had not participated in the SOGS, their vulnerability to climate change would have been higher than their current level of vulnerability and if the control group had participated in the SOGS their vulnerability would have been lower than their current level of vulnerability. This implies that, SOGS has positive effect on vulnerability to climate change for both groups.

Table 4.22: Endogenous Switching Regression Results of Treatment effects of Sorghum Outgrower Scheme on Vulnerability to Climate Change

Treatment Status	Decision to Participate	Decision Not to Participate	Treatment Effect
Treatment Group	(a)0.393	(c) 0.395	-0.002
Control Group	(d) 0.376	(b) 0.386	-0.01
Heterogeneity effects	BH_1= 0.017	BH_2= 0.009	TH= 0.008

Source Survey data, (2018)

To further confirm the treatment effect, the last column of table 4.22 contain the treatment effects results. The treatment effect is -0.002 and -0.01 for the treatment and control groups respectively. The lower treatment effect value for treatment group than the control group suggest that the SOGS has more effect on treatment group.

The last row of table 4.22 contain heterogeneity effects. The coefficient for heterogeneity effect on treatment and control groups are BH_1 =0.017 and BH_2 = 0.009 respectively. The differences in BH_1 and BH_2 suggests existence of unobserved characteristics of members in the treatment group and the control group which suggest that, the effect of SOGS on reducing SHF vulnerability to climate change is not limited to only participating in the SOGS but other unobserved characteristics such as individual skills of farmers. The transitional heterogeneity effect (TH) is 0.008 which is positive suggesting that participating in SOGS has positive effect on reducing SHF vulnerability to climate change for both treatment and control groups.

The results are consistent with empirical literature that enhancing SHF asset based through capacity building, information and support system that improve their economic activities build their adaptive capacity and make them resilience to climate change (Abdul-Razak & Kruse, 2017; Jamshidi *et al.*, 2019; Makate *et al.*, 2019). Given that the SOGS support farmers with extension services, climate information and guaranteed market leading to increase productivity and profitability, they are more likely to be less vulnerable to climate change.

The PSM results presented in Table 4.23 shows ATT and ATU estimates are -0.027 and -0.033 respectively. The PSM results are similar to the ESR results on positive effect of SOGS on reducing SHF vulnerability to climate change. There are small variations on the ATT values and ATU values with that of the ESR results on effect on SOGS on reducing SHF vulnerability to climate change.

Table 4.23: Treatment effects on Vulnerability to Climate Change

	Effect	Std. Err	T-stat
ATT	-0.027***	.003	-8.4
ATU	-0.033***	.005	-7.0
ATE	-0.031***	.004	-8.6

******* denotes significance at 1%

Source Survey data (2018)**.**

The relatively lower values of ATT compared to treatment effect of ESR results suggest that PSM overestimated the effect of SOGS on reducing SHF vulnerability to climate change on the treatment group. The differences in the treatment effect under ESR and PSM could be attributed to inability of PSM to account for unobservable characteristics of farmers that could influence their ability to reduce vulnerability to climate change apart from participating in the SOGS.

4.9.3 Summary of Smallholder Farmers Vulnerability to Climate Change

In summary, the differences in perceived vulnerability to climate change between the treatment and control observed in this study could be explained by the fact that vulnerability in itself is fluid and subject to multiple conceptualizations. Aniah *et al.* (2019) stated that farmers who have access to extension services are likely to better understand changes in the climate as extension services provide information about climate and weather. This emphasises the fact that the perception of people changes with the different services and information available to them. As the findings suggests, about 54% of farmers on the SOGS had access to extension services compared to only barely 7% of those who are not on the SOGS. For this reason, farmers on the SOGS are likely to be aware of what constitute vulnerability and can relate to climate change information that extension officers may have given them compared to those who are not and this could influence their responses during the data collection on their vulnerability to climate change.

Secondly, farmers on the SOGS view farming as a business and are likely to relate climate change and variability to business loses. They are predisposed to having a heightened sense of vulnerability in comparison to control group who may not necessarily farm for business.

The treatment group's sense of vulnerability to climate change does not necessarily suggest that they are worse off with the impact of climate change. While the treatment group may appear vulnerable, they are more resilient to the impact of climate change. Resilience in general sense means, a system's or a household's ability to deal with stresses and disturbances and maintaining its basic structure and ways of functioning, capacity for self-organisation, and capacity to learn and adapt to change(UNEP & UNDP, 2013). Since treatment group have higher productivity and profitability as the data suggest, their resource banks are likely to be better than the control group. Even though the data suggest that they are more vulnerable to climate change, being less vulnerable to adaptive capacity suggest that they are most likely to be in a better position to cope with the changes in climate and become more resilient compared to the control group.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter summarises issues raised in chapter one, the methods used to investigate them and the key findings. Conclusion of the study, recommendations for policy makers, research gaps and direction for future research are all presented in this chapter.

5.2 Summary and Major Findings

The role of smallholder farmers in Ghana's agricultural development is highly acknowledged by all stakeholders. Their contribution is however, limited by diverse constraints leading to low productivity, high postharvest losses and low profitability. Their livelihoods are further worsened by negative impact of climate which is making them vulnerable. Approaches adopted by policy makers to optimise SHF economic activities have not yielded much results. Smallholder farmers still produced far below their potentials and remained the poorest among the poor.

The OGS concept is recommended globally as an ideal approach to transform SHF farmers activities as it support them with productive resources, knowledge and guaranteed market. Regardless of the optimism expressed by several literature on importance of OGS in transforming the activities of SHF, there is limited research on its effect on the livelihoods of SHF producing indigenous crops like sorghum in Ghana.

This thesis analysed the effects of OGS to establish whether participation has any effects on the livelihoods of smallholder sorghum farmers in northern Ghana or not. The specific objectives of the thesis were to identify factors influencing SHF participation in SOGS; examine the effects of OGS on SHF productivity, postharvest losses, profitability and the effects on reducing their vulnerability to climate change.

Using multistage sampling procedure, primary and secondary data was sourced qualitatively and quantitatively. The secondary data focused mainly on documentary analysis of published and unpublished literature and time series data from the Ghana Meteorological Agency. The qualitative data from primary sources were mainly from lead farmers, FGD and face-to-face interviews. The quantitative data from primary source was obtained from 516 SHF households on treatment and control groups.

The data was analysed both quantitatively and qualitatively and integrated at the report writing stage. The quantitative data was captured electronically using CAPI and transferred onto a platform and analysed using STATA version 15. The ESRM was employed to address selectivity bias to determine the effects of SOGS on the livelihoods of SHF while PSM technique was adopted for robustness check. The following were findings of the thesis:

1.0 Out of 15 variables modelled using probit regression to determine the factors influencing SHF participation in SOGS, 11 variables were found to be statistically significant and influencing participation. The most important among the variables were age of the farmer, gender of the farmer, access to market, extension services and being a member of FBO. The study found older and female farmers less likely to participate relative to younger and male farmers respectively. While relatively younger farmers interest in participation signifies brighter future for sustainability of the SOGS, the likelihood of more male farmers participating compare to female farmers present a glooming picture for the efforts to bridge gender inequality between men and women on access to productive resources such as land.

Smallholder farmers participation being influenced by market access explains the role of market in reorienting the mindset of SHF from their subsistence farming practices to farming as a business. Being a member of FBO was also found to positively influence SHF participation in SOGS.

In conclusion, being a male farmer, SHF expectation of access to guaranteed market and belonging to FBO are the most important factors influencing their participation in the SOGS. This result is consistent with the hypothesis of the thesis.

2.0 The results on productivity suggest that the average productivity of SHF on the treatment group was 1,207kg/ha and control group was 820 kg/ha. The counterfactual outcome from the ESR shows that if the treatment group had decided not to participate, their productivity would have been lower and if the control group had decided to participate, their productivity would have been higher. The findings suggest a positive effect of SOGS on the productivity of both groups but the effect is higher for the treatment group than the control group.

This implies that the OGS has unequal effect on random smallholder sorghum farmer who choose to join the scheme. The results illustrate existence of unobserved heterogeneity effects which influence their participation decision and at the same time make them more productive than a random smallholder farmer who choose to join the scheme. The result is inconsistent with the hypothesis of the thesis that SOGS increase productivity of all smallholder farmers who participate in the SOGS. In conclusion, the thesis argues that the outgrower scheme concept in its current form favours who are endowed with productive resources.

For profitability, the study found profitability to be GHS 575/ha and GHS504/ha for treatment and control group respectively. The ESR on counterfactual outcomes suggest that had the treatment group choose not to participate in the SOGS, they would have made losses of GHS 482/ha and if the control group had decided to participate, they would have realised profitability of GHS 43/ha against their current losses of GHS 93/ha. The findings imply that SOGS has positive effect on profitability for both the treatment and the control group but the effect is higher for the treatment group than the control group.

Inclusion, the smallholder sorghum farmers could increase their profitability by participating in the SOGS. But the margin of profitability will largely depend on intrinsic characteristic of the farmer of which farmers who are endowed with resources are likely to have more profitability. The finding is inconsistent with the hypotheses of the thesis that, OGS has effect on the profitability of any smallholder sorghum farmer who choose to join the OGS.

On postharvest losses, the treatment and control groups loss 161 kg/ha and 127 kg/ha respectively. Average value losses are GHS193/ha and 166/ha, and average percentage losses are 14.24% and 27.22 % respectively for the treatment and the control groups. The result show that on real terms, the treatment group loss more produces due to PHL than the control group but on percentage terms, the control group loss more sorghum than the treatment group. The counterfactual outcomes show that if the treatment group had not participated in the SOGS, they would have recorded losses higher than their current losses and if the control group were to participate, they would have recorded lower than their current losses. In conclusion, random SHF who choose to participate in SOGS will reduce their postharvest losses compare to not participating. The finding is consistent with the hypothesis of the thesis that participating in OGS help to reduce SHF postharvest losses.

3.0 The LVI results on smallholder farmers vulnerability to climate change shows that both the treatment and control groups are vulnerable to climate change with the treatment group being relatively more vulnerable than the control group. For the LVI-IPCC results on contributing factors to vulnerability, the treatment group is more vulnerable in the area of sensitivity and exposure than the control group but less vulnerable in adaptive capacity than the control group.

The ESR results on treatment effects of SOGS on reducing smallholder farmers vulnerability to climate change suggest that the SOGS has minimal effect on vulnerability to climate change. The limited effect of the SOGS to smallholder farmers vulnerability to climate change could be due to the buyers not providing support in the area of water, food and health major components as part of the OGS package to farmers. The result is inconsistent with the hypotheses of the study that SOGS scheme reduces smallholder farmers vulnerability to climate change.

In conclusion, the current sorghum outgrower scheme promoted by Guinness Ghana Brewery Limited is largely on unequal demand and supply bases which skew the capture of benefits towards the buyers. The is not a pro-poor scheme and may suffer high exit rate leading to unsustainability in future if the concept is not modify to consider the welfare of farmers as part of the scheme package.

5.3. Recommendation

Given that Ghana’s agricultural sector is dominated by older farmers and also given the low interest of the youth to take farming as a business, the probability of relatively younger people likely to participate in the sorghum outgrower scheme compared to relatively older people provide opportunity to attract more youth into farming through the SOGS. Also, the scheme giving preference to farmers who belong to FBO suggests that when the youth are encouraged to join FBO their participation in OGS would increase. Any government policy that promote the youth to join FBO could increase their participation in OGS leading to more youth developing interest in farming. Market access was another important factor influencing participation. The efforts to transform smallholder subsistence farming to market-oriented farming can be achieved through investing in projects that can provide guaranteed market for SHF. Increase investment in market infrastructure such as feeder roads and storage facilities will increase market access and attract more people to go into farming.

To increase productivity, reduces postharvest losses and increase profitability of smallholder farmers, government could consider modifying the current outgrower scheme to make it pro-poor and adopt it in the implementation of the government agricultural flagship programmes such as the *planting for food and jobs, rearing for food and jobs and planting for export and rural development* which sought to increase smallholder farmer's livelihood outcomes. Smallholder farmers will benefit more by increasing their productivity, their postharvest loss reduction and their profitability from government support such as fertilizer and seed subsidy programme, extension services and marketing arrangement through channelling the support to private investors under OGS arrangement with government playing a coordination and monitoring to ensure mutual benefit.

On climate change, the results suggest that, smallholder farmers in the study area are vulnerable to climate change. The ESR results on effects of SOGS on reducing smallholder farmers vulnerability to climate change suggests that the SOGS has minimal effect on reducing vulnerability. For the current outgrower scheme to become sustainable, the thesis recommend to private sector promoting the scheme to consider including welfare variables such as access to water, food and access to health care as part of the outgrower scheme package.

Given the global call for nations to increase their efforts to reduce the effect of climate change and the efforts by Ghana government to help smallholder farmers become less vulnerable to climate change, to achieve this goal, this thesis recommend to government to adopt and modify the current outrgrower scheme to include welfare variables such as access to water, food and health care as part of the outgrower scheme concept.

Suggestion for Future Research: Given the importance of SOGS in addressing the constraints of SHF, future research should broaden the study areas to cover different ecological and socio-cultural locations that will allow for comparison of performance. This will help to understand how different ecological and cultural dynamics affect sorghum outgrower scheme outcomes. This research was limited to only two regions due to limited resources and time constraints.

Secondly, the changes in climate has different implications on smallholder farmer's productivity, profitability and their vulnerability to climate change in different years. In a year of stable weather, farmers may obtain higher productivity and profitability. Panel data that explains trend of productivity and profitability of farmers on SOGS across different years will provide more robust results. This study used cross-sectional data due to lack of existing time series data on SOGS and limited time frame for the study to collect time series data. Future research could focus on gathering time series data.

On effect of SOGS on postharvest loss reduction, the study focuses on only on quantity and value losses. Future research could consider quality loss, especially aflatoxin contamination. Considering the background of the researcher, the study was limited to quantity and value losses.

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APPENDICES

Appendix 1: Questionnaire

SURVEY QUESTIONNAIRE

My name is Charles Nyaaba, a PhD candidate at the University of Ghana, Legon and I am conducting a research on the topic *"The effects of Outgrower Scheme on the Livelihoods of Smallholder Sorghum Farmers in Northern Ghana".* You have been identified as a knowledgeable informant on this topic and hence I will be very grateful if could spend some time to assist me complete this questionnaire. This study is purely an academic exercise as such all information provided will be treated strictly as confidential and for academic purposes only. Responses will be used anonymously and cannot be traced to the persons who provide them. Thank you in advance for your time and contribution to this research.

Questionnaire Number	
Date of interview *(mm/dd/yyyy):*	
Region:	1. Upper East 2. Upper West
District:	
Community Name	
Language Used for Interview	1. English 2. Ga-Adangbe 3. Nzema 4. Akan 5. Dagbani 6. Ewe 7. Hausa 8. Dagaare 9. Other __________ (Specify)
Name of Enumerator:	
Name of Respondent	
Contact Number of Respondent	

MODULE A: DEMOGRAPHY

Ask these questions for each of the members that have stayed with this Household for a period of **<u>at least six month</u>** over the last 12 months.

(Household members are defined as all those who normally live and eat their meals together here. Include household members temporarily studying elsewhere or ***traveling, but who spent AT LEAST SIX continuous months living and share the same cooking arrangements).***

Reference Period: The Past 12 months

Member ID & Name (Start with the household head)		Common Name	What is the **sex** of [NAME]? 1=male 2=female	How old is Name	Relationship to current head See code below	Is name the primary respondent 1=Yes 2=No	What is [Name]'s Nationality?	What is Name's religious denomination	[Name]'s Marital Status (ask only if **A04> 12**) See codes below	If A05<3 yrs What is the **highest** level of education [Name]'s has completed? see codes below	Is [NAME] currently attending school? 1 = Yes>> A13 2= No	If **<u>A11</u>**=2, Why is [NAME] not in school?	Can [NAME] read? 1=Yes 2=No	Can [NAME] write? 1=Yes 2=No	What is the **MAIN** occupation of [NAME]?	Answer for household members older than 12 years.	
																Did [Name] receive cash from informal /business activity? Include dividends (in the past 12 months) 1=Yes 2=No	Did [Name] receive cash or payment in kind from salaried employment, wage activities, <u>remittances</u> or pensions? (in the past 12 months) 1=Yes 2=No
A01	A02		A03	A04	A05	A06	A07	A08	A09	A10	A11	A12	A13	A14	A15	A16	A17
1																	
2																	
3																	

4																		
5																		
6																		
7																		
8																		
9																		
100																		

Relation to head (A05)		Marital Status (A09)	Nationality (A07)	Education levels (A08)	Religious Denomination	Reason for absence from school (A12)	Main Occupation (A15)	
1= head 2= spouse 3= own child 4= step child 5= parent 6= brother /sister 7= nephew /niece 8= son/daughter-in-law 9= grandchild	10=other relative 11=non-relative 12=brother /sister-in-law 13=parent-in-law 14=Worker 15=Adopted child 16=Grand parent	1 = single 2 = monogamous married 3 = polygamous married 4 = divorced 5 = widowed 6 = separated 7=Cohabitation	1.Ghanaian 2. Nigerian 3. Burkinabe 4. Nigerien 5. Liberian 6. Malian 7. Togolese 8.Other Ecowas 9.Other African 10.Other Continent	None..................................00 Kindergarten......................01 Primary…………………...02 JSS/JHS/Middle………….03 SSS/SHS/O'level/A'level…04 Voc/Tech/Commercial……05 Teacher Training/Agric/Nursing Cert……............................06 Degree…………………….07 Post-graduate……………08 Other……………………...09 Don't know………………99	1.No religion 1 2.Catholic 2 3.Protestant 3 4.Pentecostal/Charismatic 5.Other christian 6.Islam 7.Traditional 8.Other	0=Too young 1=Cannot afford expenses 2=Working 4=Pregnancy 5=Sickness/disability 6=Refused to continue 7=Completed schooling 8=Too old to be in school 9=Other (specify)___	1= Salary earner (e.g., teacher, policeman, etc.) 2= Casual wage earner 3= Farm labourer 4=Transportation business 5= Bicycle repair/mechanics 6= Brewing business 7= Brick making 8=Butcher 9=Carpentry 10=Charcoal burning 11=Clothes business (trading) 12=Construction 13=General-kiosk owner	14=Miller 15=Trading farm produce 16=Trading food items 17=Trading livestock 18=Trading firewood/timber 19=Trading non-food goods 20=Farming 21=Tailor 22=Schooling 24=Food vendors 23=Other (specify)

SECTION A: SOCIOECONOMIC CHARACTERISTICS

1. How many children in your household are orphans …………..
2. How long have you been farming……………. Number of years
3. What is your length of stay in this community …………… Number of years
4. How many people in your family go to a different community to work? ....
5. Do you belong to any Farmer Based Organisation (FBO)? a. Yes b. No
6. What is the name of the FBO………………………………

SECTION B: FARM CHARACTERISTICS

7. What is the total area of your land (include both owned and rented areas that the farmer farms in and around the village)? ....Acre(s)
8. How many sorghum farms did you cultivate? …………..Number of plots
9. What is the size of your sorghum farm cultivated during the last production season? ……….acre(s)
10. What is the land tenure situation that best describe your farm?
    1. Producer owns land
    2. Producer pays money to rent all the land
    3. The land is under communal ownership
    4. Producer farms land owned by other without paying anything
    5. Producer exchanges produce for rights to all land farmed (sharecropping)
11. What variety of sorghum is cultivated on your farm?
    1. local (specify name of variety)………………………………………………………….
    2. Naga white 2. Framida 3. Kadaga 4. Kapaala 5. Dorado 6. Other improved variety (specify)…………………………………………………………
12. What is the distance from your homestead to the farm? ....Kilometers

SECTION C: SORGHUM OUTGROWER SCHEME

13. Do you participate in sorghum outgrower scheme? 1. Yes 2. No >>
14. Do you have any contract with an aggregator to supply them with sorghum? 1. Yes 2. No >>
15. If yes, which aggregator are you in contract with ? a. Faranaya b. PFAG c. Agric Access d. other specify
16. What kind of agreement is it? a. Oral b. Documented
17. How many years have you been enrolled under the sorghum outgrower scheme…………….(Years)
18. Did you receive some support from the Outgrower scheme in the last production season? 1. Yes 2. No >>
19. What kind of technical assistance do you receive from the Outgrower scheme? Multiple response 1. Fertiliser 2. Pesticide 3. Training 4.credit (financial support) 5. Tools/equipment 6. Seeds 7. Other specify…………………………………………………..
20. How was the price determined?
    1. Arrangement between the aggregator and farmer 2. Farmer determines the price 3. Prevailing market price 4. Aggregator determines the price 5. Other specify………………

SECTION D: TRAINING SERVICES

21. Did you receive extension visit in the last production year? 1. Yes 2. No >>
22. How many times did you receive extension visit in the last production………………? Number of times
23. What kind service did you receive from the extension agent? Circle all that apply

1. Improving sorghum farming practices or processing practices	2. Improving record keeping	3. Marketing support Information
4. Health and social issues	5. Environmental issues	6. Managing the farm's business or finances
7. Crop losses	8. Adult literacy	9. Other (specify)

24. Did you receive any other training other extension service? 1. Yes 2. No >>
25. Did you receive any other training other than extension service? 1. Yes 2. No (Skip to Q)
26. Who provided the training service? Circle all that apply

1. NGO	2. Aggregator/Buyer	3. Research Institute/University
4. Other (specify		

27. What kind of training did you receive? Circle all that apply

1. Improving sorghum farming practices or processing practices	2. Improving record keeping	3. Marketing support Information
4. Health and social issues	5. Environmental issues	6. Managing the farm's business or finances
7. Adult literacy	8 Other (specify)	

28. How many training sessions were attended?	……………….... (Number)
29. How many minutes were spent travelling to attend this training?	……..………. Minutes
30. What was the cost of this travel?	……………….................. . Amount in Ghana cedis

SECTION E: ACCESS TO CREDIT

31. Did you try to get credit or loan for sorghum production in the last production season?
    1. Yes 2. No >> Section F

LN	Sources from which loans were requested	Did you try to get credit/loan from this source 1.Yes 2. No>> next source	Amount requested from this source (If several loans were requested from one source, show total of all requests)	Amount received from this source	Interest paid per anum (Percent)	Have you paid (fully) back the loan received? 1. Yes>>next source 2. No	What is the outstandin g loan to be paid? Amount in GHS
LN	42A	42B	42C	42D	42E	42F	42G
1	Friends						
2	Relatives						
3	Religious groups						
4	Banks						
5	Government lending Institutions						
6	Non-Bank Financial Institution						
7	Buyers/Aggregator directly						
8	NGOs						
9	Cooperatives						
10	Farmer Based Organisation						

60. Did you lend any money to relatives/friends in the past 12 months? [ ] 1=Yes 0 = No

SECTION F: INPUTS USED IN FARM PRODUCTION

32. In the last production season, did you apply fertiliser or pesticide on your sorghum farm?
    1. Yes 2. No >> Section G

Input	Did you use this input in the last production season? 1.Yes 2. No >> Next input	How did you obtain the chemical fertiliser?	What quantity of the chemical fertiliser did you use?.	Unit 1. Gram 2. Litre	If some or all the chemical fertiliser was purchased, what was the total amount paid?	What was the value of the chemical fertiliser used in the last production season (including chemical fertiliiser

						subsidised or obtained as gift)
42A	42B	42C	42D	42E	42F	42G
Chemical fertiliser						
Organic fertiliser						
Pesticide						

Code for

1. Purchased from Agro-input dealer 2. Purchased from the market 3.Borrowed (loan) 4. Gift 5. Organisation came to community 6. Aggregator 7. Government/MOFA/Govt. Organisation 8. Other specify……………………………….

SECTION G: HARVEST AND HARVESTING ACTIVITIES

43. How do you harvest your produce? Tick the appropriate responses

1. Manual with/without cutlass 2. Employ additional labour using the sickle/knife 3. Use a machine harvester

4. Others (specify)…………………………………………

44. How do you check for the maturity of your produce before harvesting? Tick the appropriate responses
1. By hand feel 2. By visual observation 3. Uses an instrument to measure 4. Uses days after planting as index

5. Others (specify) ……………………………….

45. What harvesting method did you use in the last production season?

1. Mechanical (use of tractors) 2. Manual (labourers)

46. What quantity of sorghum was harvested from your farm in the last production season? …………….

Unit 1. Kg 2. Maxi bag 3. Mini bag

47. What quantity of sorghum did you <u>expect</u> to harvest from your farm?....................

Unit 1. Kg 2. Maxi bag 3. Mini bag

48. While still in the field, was any sorghum damaged? 1. Yes 2. No >>

49. What was the crop lost to?

1. Rotting 2. Diseased 3. Fire 4. Flood 5. Drought 6. Birds 7. Insects 8. Rodents 9. Sheep 10. Goat 11. Cattle 12. Other

50. How much of the sorghum did you lose in total during harvesting?..........................

Unit 1. Kg 2. Maxi bag 3. Mini bag

SECTION H: POST HANDLING ACTIVITIES AND POST HARVEST LOSS

Stacking/Heaping

51. Did you heap/stack the harvested produce on the farm before transporting? 1. Yes 2. No >>

52. What quantity of sorghum was lost during heaping……………………. Unit 1. Kg 2. Maxi bag 3. Mini bag

53. What is the value sorghum lost during heaping or stacking …………………… GHS

Transporting to the from Farm gate to homestead

54. Do you readily get transport to cart your agricultural produce to the market centres? 1. Yes 2. No >>

55. How do you usually transport purchased agricultural commodities to your point of sale?

1.by own Donkey 2. by appropriate rented/hired vehicle 3. by any available passing commercial vehicle 4. by own non-motorized truck 5. by appropriate rented/hired truck 6. by any available head-load porter 7. bicycle 8. Other…………………………

56. How much did you spend on transporting sorghum from the farm to homestead………………. GHS

57. What is the distance from the farm to your homestead………………. Km
58. Did you incur any sorghum loss from the farm gate (loading into the vehicle) to the homestead?

1. Yes 2. No >>

59. What quantity of sorghum was lost when transporting the produce from the farm gate to the homestead…………..

Unit 1. Kg 2. Maxi bag 3. Mini bag

60. What is the value of sorghum lost when transporting from the farm gate to your homestead?................... GHS

Drying

61. Did you dry your produce? 1. Yes 2. No >>
62. Did you experience crop losses during sun-drying? 1. Yes 2. No >>
63. What was the sorghum lost to during drying

1. Wind 2. Over-heating 3. Microbial infestation 4. Birds 5. Insects 6. Other specify …………………...

64. What quantity of sorghum was lost during drying ……………… Unit 1. Kg 2. Maxi bag 3. Mini bag

Winnowing/Threshing

65. Did you thresh your sorghum after harvesting? 1. Yes 2. No >>
66. How did you thresh your sorghum?
    1. Mortar and pestle 2. Beating with sticks 3. Motorized thresher 4. Other specify…………………….
67. What was the expected quantity of sorghum before threshing…………………….

Unit 1. Kg 2. Maxi bag 3. Mini bag

What was the quantity loss of sorghum after threshing ……………. Unit 1. Kg 2. Maxi bag 3. Mini bag

68. During winnowing what quantity of the sorghum was lost? ……………. Unit 1. Kg 2. Maxi bag 3. Mini bag

Grading and Bagging

69. Do you grade your produce immediately after threshing and winnowing? 1. Yes 2. No
70. What quality indices do you use for grading your produce? Tick the appropriate responses

1. Colour 2. Size 3. Weights 4. Shape 5. Physical blemishes 6. Others (specify)………………………

24. What quantity of sorghum was lost during grading …………….. Unit 1. Kg 2. Maxi bag 3. Mini bag

25. What quantity of the sorghum was bagged for storage………….. Unit 1. Kg 2. Maxi bag 3. Mini bag

SECTION I: STORAGE PRACTICES AND CROP LOSSES AT STORAGE

1. Did you store some of the produce after harvest? 1. Yes 2. No >>
2. What facility do you use for the storage of sorghum harvested?
   1. Traditional crib 2. Improved crib 3. Room 4. Other (specify)……………………………
3. How do you store produce before marketing?
   1. On a platform uncovered (tarpaulin) 2. Off-farm own shed 3. On bare floor uncovered
   4. Government silo 5. On platform covered 6. Barns 7. On bare floor covered 8. Cribs
   9. In containers 10. In plastic and jute sacs 11. On-Farm own shed 12. Others (Specify)
23. During the last 12 months, has any of the stored crop been lost to rot, pest, or any other cause?
   1. Yes 2. No >>

30. What has the sorghum stored been lost to?

1. Rotting	2. Aflatoxin/Mould	3. Fire	4. Birds	5. Insects
6. Rodents	7. Sheep	8. Goat	9. Cattle	10. Other

31. What quantity of the sorghum was lost during storage ………………
   Unit 1. Kg 2. Maxi bag 3. Mini bag
32. What is the value of crop lost at storage? .... GHS
33. What is the distance from your homestead to the nearest storage facility………….. Km

Transporting to the from Homestead to the Sales point/Market

Do you readily get transport to cart your agricultural produce to the market centres? 1. Yes 2. No >>

How did you transport sorghum to your point of sale?

1.by own Donkey 2. by appropriate rented/hired vehicle 3. by any available passing commercial vehicle 4. by own non-motorized truck 5. by appropriate rented/hired truck 6. by any available head-load porter 7. bicycle

8. other

How much did you spend on transporting sorghum from the farm to sales point/market………………. GHS

What is the distance from the homestead to your nearest market………………. Km

Did you incur any sorghum loss from while transporting to the point of sale? 1. Yes 2. No

What quantity of sorghum was lost when transporting the produce from the home to the sales point…………..

Unit 1. Kg 2. Maxi bag 3. Mini bag

What is the value of sorghum lost when transporting from the homestead to the point of sale?................ GHS

SECTION J: CROP SALES AND CONSUMPTION

34. What quantity of the harvested sorghum did you to sell? ....
    Unit 1. Kg 2. Maxi bag 3. Mini bag
35. What quantity of the harvested sorghum did your household consume ………….
    Unit 1. Kg 2. Maxi bag 3. Mini bag
36. What quantity of the sorghum harvested was given out as gift ………..
    Unit 1. Kg 2. Maxi bag 3. Mini bag
37. How much did you receive from sales of sorghum harvested in the major season? ………… GHS
38. Where does your family get most of its food?
    1. Own harvest 2. Purchased 3. Gift from friends and family 4. Other specify…………………
39. Does your household have adequate food throughout the year? 1. Yes 0. No
40. If no, how many months in a year does this household experience food shortage [………]

SECTION K: INFORMATION ON LABOUR

Activity	30a. Days to do this job in the last production year	30b. Hours per day to do this job	30c. Number of workers used	30d. How many of the workers were hired	30e. How much was paid to hired labour	30f. How many of the workers involved in this job were household members	30g. How many workers involved in this job were exchanged labourers (Nnoboa)	How much would you have paid to unpaid labourers (household & Exchanged labour)
1. Clearing								
2. Ploughing								
3. Planting								
4.Planting of seeds								
5. Fertiliser Application								
6.Harvesting								
7. Threshing								
8. Winnowing								

SECTION L: OTHER CROPS CULTIVATED

Do you cultivate other crops other than sorghum? 1. Yes 2. No >>

What crops did you cultivate last season (2013)?	Area cultivated (hectares)	Harvest of this crop per planting season (100kg)	Percentage consumed	Percentage sold	Total value of crops Harvested (GHS)

Does this household save seeds to cultivate in the next planting season/year? 1. Yes 2. No

SECTION L: AVAILABILITY AND ACCESS TO INFRASTRUCTURE

1. Does any member of your household work outside this community? […….] 1. Yes 2. No
2. What is the main source of water for drinking and for household chores? […….] 1. Pipe borne 2. Dam 3. Rain 4. River, lake, stream 5. Wells 6. Borehole 7. Other specify …..……………………………….
3. How long (in minutes) does it take to get to the water source on foot? […………]
4. How long (in minutes) does it take to get to the water source on bicycle? [………..]
5. Has water availability been a problem? 1. Yes 0. No
6. Estimate the number of buckets (Size 34) of water stored everyday………
7. In the past, have you heard about any conflicts over water in this community? [..........] 1. Yes 0. No
8. Does your household have adequate food throughout the year? 1. Yes 0. No
9. How long in (minutes) does it take to get to a health facility? […………]
10. Do any of the household members have a chronic illness? [……..] 1. Yes 0. No
11. Has any member of the household been very ill in the past 6 months that they had to miss work or school? […….] 1 = Yes 0 = No
12. How many months in a year is malaria particularly common? [……………….]
13. Which months of the year is malaria particularly bad? Select all that apply
    1. January 2. February 3. March 4. April 5. May 6. June 7 July 8. August 9. September
    10. October 11. November 12. December
14. How many mosquito nets does the household have? [………………]

SOCIAL NETWORK

15. In the past month, did relatives or friends help you and your family (e.g., Get medical care or medicines, Sell animal products or other goods produced by family, Take care of children)? 1. Yes 2. No >>
16. How many times did you or relative receive this help in the last month………
17. In the past month, did you and or your family help relatives or friends: (same choices as above) 1. Yes 2. No >>
18. How many times did you or your family offered this help in the last month…………

19. In the past 12 months, has any member of your household gone to your community leader for help (e.g., Chief, Assemblyman, Member of parliament etc.)? […………]   1. Yes   2. No
20. Do you play a leadership role in any social organisation in this? 1. Yes   0. No
21. In the past 12 months, have you or someone in your family gone to your community leader for help? 1. Yes   2. No

SECTION M: CLIMATE CHANGE

63. Have you noticed any changes in the weather pattern in the past 30years? 1. Yes   2. No

65. What changes have been observed in the temperature pattern?

1. Consistent   2. Do not understand   3. Decreased   4. Increased

66. What changes have been observed in the rainfall pattern?

1. Consistent   2. Do not understand   3. Decreased   4. Increased

67. Has your household suffered from any drought or flood since 2000? 1. Yes   2. No >>

68. Did you receive any warning about the flood or drought before it happened? 1. Yes   2. No

69. Did any member of your household sustain any injury or lost their life as a result of the flood or drought?

1. Yes   2. No >>

70. Indicate the number that got injured [.........]/ passed away [……..]

71. Did you lose any livestock as a result of the flood or drought? 1. Yes   2. No

72. Was there any loss in the value of your livestock as a result of the flood or drought? 1. Yes   2. No

73. Did you received any training/support on how to withstand the changes on climate? 1. Yes 2. No >>

74. who provided the training (Multiple Choice)? 1. Aggregators/ buyers 2. Outgrower Scheme officers 3. MoFA 4. NGOs 5. Ghana Metrological Agency

75. What type of training/support was given (multiple choice)? 1. Using early maturing seed varieties 2. Change the type of crops planted 3. Change from crop farming to livestock farming 4. Combine crop with livestock farming 5. Information on when to plant 6. Information on when to harvest 7. Engage in off-farm activities 8. Any other

76. Has the training or the support help you become resistant to climate stress? 1. Yes 2. No

HOUSEHOLD HUNGER SCALE

During the WORST MONTH, how often did you or any other HH member…

77. Have to go for a **whole day** and **night completely** without food **due** to **lack of resources** to get food?

1. Never   2. Rarely (1-2 times)   3. Sometimes (3-5 times)   4. Often (5+ times)

78. Have to sleep at **night** hungry because there was **not** enough food?

1. Never   2. Rarely (1-2 times)   3. Sometimes (3-5 times)   4. Often (5+ times)

79. Have to go a **whole day and night without** eating anything at all because there was **not** enough food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

80. Have to **limit the frequency** of meals because of lack of resources?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

81. Have to eat a **smaller meal** than you felt you needed because of lack of resources/food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

82. Have to eat food that you **did not like** to eat because of a lack of resources to obtain other types of food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

83. Have to limit the **variety** of foods you ate because of lack of resources?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

SECTION N: ASSETS

Circle the items the household owns and provide the current value or amount paid			
	Item	**Number**	**Number**
1	Radio	…………………	Cedis……………
2	Television	…………………	Cedis……………
3	Mobile Phone	…………………	Cedis…………...
4	Bicycle	……………………	Cedis……………
5	Refrigerator	……………………	Cedis……………

SECTION O: LIVESTOCK OWNED

Do you own livestock? 1. Yes 2. No >> End Interview

Livestock	Do you own this livestock 1.Yes 2. No >> Next livestock	How many do you own (Number)	What is the value of the livestock owned (Amount in Ghana cedis)
Cattle			
Draught animals (oxen, donkeys, horses etc.)			
Poultry			
Rabbits			
Sheep			
Goats			
Pigs			
Fish (estimate number)			
Beehives			
Others (Please specify)			

Appendix 2: Interview Guide

Interview guide for FGD and individual interviews

Questionnaire for FGD

Date of Interview:	Interviewer:
Location:	Protocol:
Duration:	Translator:
Section 1: Basic Info on group >General Status quo Analysis	
History of the group: Could you please give a brief history of your group?	
Year of registration?	
Reason for group formation?	
Number of group members (m/f)?	
Popular crop grow and reason for that crop?	
Average farm size?	
Do you have experiences with OGS?	a. Yes b. no
Are you currently in any OGS?	a. Yes b. no proceed with section 3
Section 2: formality of contractual arrangements under the OGS	
2a Could you please tell us more about your OGS, who the contractor is and how it came into being!	
What motivated your participation in the OGS? Probe for details and multiple explanation	
What is in the sorghum OGS that motivated your participation?	
Is there specific requirement to meet before consider to join the OGS?	
Who is your current contractor (buyer/aggregator)?	
How did it come into being, who was the initiator? Did you have any guidance in designing or negotiating contract terms? How much time did you have to discuss the contract with group members?	
For how many years have you been farming under the OGS arrangement? • With the current contractor? • With others? • Which products?	
Who was negotiating the current contract and how?	
2b kindly list and explain more about specific elements of your current OGS arrangement such as the product, quantity, quality, delivery period etc.	
What is the contract duration?	a. Year b. 6 months others:
Produce	

Quantity/planting programme	
Prices	a. fixed at b. minimum or range
Quality, specified and how?	a. Yes b. no
Who does the grading?	a. Farmers b. special graders c. contractor d. aggregator.
Input supply: Who supply what? Farmer and buyer /contractor?	
Seeds	a. Farmer b. buyer c. GGBL
Fertilizer	a. Farmer b. buyer c. GGBL
Chemicals, pesticides, herbicides	a. Farmer b. buyer c. GGBL
Postharvest support (Harvesters, tarpaulin, sacks, scales)	a. Farmer b. buyer c. aggregator d. GGBL
In case you are paid by cheque: How much do you pay to cash the cheque?	
When/how is the loan deducted from your sales?	
What percentage goes into servicing credit?	
Is there an interest rate?	
External support: Could you please tell us what kind of external support you receive in the various areas of production and marketing and by whom!	
Production	how often: □□no
Chemical application	how often: □□no
Record keeping	how often: □□no
Water management	how often: □□no
Gap training	how often: □□no
grading	how often: □□no
Do you know where to get advice or information on OGS?	
Transport of produce: Could you please tell us more about the way the transport of your produce is organised?	
Where is the produce picked up?	
Distance from pick up point to next main road or factory.	
How often is the produce picked up?	
Who pays the transport costs?	

Are there documents, which have to accompany the produce (traceability)?
To whom do the bags belong?
Rejection of produce: What is your experience with rejections of your produce?
Is there anything mentioned in the contract how to deal with rejections? (price reduction)
Where does the rejection take place?
How is it justified? What are reasons?
Do you have a possibility to intervene?
What happens with the produce when it has been rejected?
Legal issues in the contract and its enforcement
Please tell us whether the contract has an exit/termination clause for both parties?
Are there clear sanctions to mitigate breach?
Is an arbitrator specified?
How to deal with force majeure/natural calamities/natural risks? Is there risk sharing?
Who signed the contract? Any witnesses present (MoFA)?
Group mechanisms/group management: Could you please tell us more about your mechanism and the way in which you manage your group!
Are there charges for group management?
Does the group have written by-laws (rules and regulations including sanctions)?
How often do you meet?
Standards: Could you please tell us your experience with standards such as aflatoxin?

2c Are there any things you would like to be added to/regulated by your contract? How should the ideal contract look like?
2d What kind of support do you wish for your future engagement in OGS?
2e Problems/challenges faced by the group: Please tell us the problems you were faced with since you entered into OGS?
Was there contract breach?
Who breached the contract and why?
Pick up of produce
Mode of payment
Price

Input supply
Quality of seeds
Efficacy of chemicals
Extension service, support, training
Quality of fertilizers
2e Advantages/disadvantages of OGS
Which advantages do you see for you as a farmer group being engaged in OGS?
Which disadvantages do you see for you as a farmer group being engaged into OGS
Which advantages do you think does the buyer have when engaged in OGS?
Which problems do you think does the buyer face when engaged in OGS?
Section 3: Informal arrangements (no CF experiences)
3a You told us that you don't have any experiences with OGS. So please tell us more about the way you market your produce!
How do you market your produce at the moment?
Where do you market your produce at the moment?
Are you satisfied with your current marketing system?
4. What is you understanding of climate change?
What factors explain climate change in your opinion?
Have you observed any changes in the last 30 years?
What is the impact on your farming activities (positive and negative)? probe for details
Has the climate change impacted on your livelihoods? probe for details
Do you receive any training/support on climate change by the OGS?
What kind of training/support was given?
Who provide the training/support?
Has the training/ support received has any impact on your farming activities (positive/negative)? Probe for details
Do you have any question, comment and contribution on climate change?

Further guiding questions for expert interviews:

- What is sorghum farming like (production, profitability, postharvest loss)?
- What do you think the role of institutions like MoFA should be in order to improve the current situation in OGS?
- What are the main driving forces for participating in OGS?
- What are criteria for consideration when contracting farmer groups (size, volume delivered, establishment of the group, location in a certain area)?
- How is the process/what are the steps in contracting new farmer groups?

- Which are the challenges/problems you are faced with as a processor/buyer concerning farmers you are working with and buyers in Ghana?
- Does all the produce you are processing/packing come from formally contracted “out-growers”?
- What is the climate change situation like?
- Were you given training/supported on how farmers could adapt to the climate change?
- What kind of training/support was given?
- Has the training or support made farmers resilient to climate change?

Appendix 3: Postharvest Loss Along the Various Postharvest Chain

Table A1: Causes of Sorghum Losses During Heaping

	Treatment		Control		Overall	
	Freq.	Percent of cases	Freq.	Percent of cases	Freq.	Percent of cases
High rainfall	4	21.1	24	25.0	28	24.4
Delay heaping	6	31.6	20	20.8	26	22.6
Lack of good platforms to heap sorghum	15	79.0	68	70.8	83	72.2
Birds attack	2	10.5	50	52.1	52	45.2
Livestock attack	3	15.8	43	44.8	46	40.0
Fire outbreak	0	0.0	2	2.1	2	1.7
Other specify	2	10.5	12	12.5	14	12.2

Table A2: Causes of Sorghum Loss During Transportation

	Treatment		Control		Overall	
	Freq.	Percent of Cases	Freq.	Percent of Cases	Freq.	Percent of Cases
Poor roads	16	80	24	63.2	40	68.97
Lack of appropriate vehicles	13	65	23	60.5	36	62.07
High cost of transport	3	15	13	35.2	16	27.59
Distance from farm to storage centres	13	65	20	52.6	33	56.9
Other specify	2	10	3	7.9	5	8.62

Table A3: Causes of Sorghum loss During Drying

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Rodents attack	30	10.0	7	3.2	37	7.2
rainfall/high moisture	77	25.7	67	31.0	144	27.9
high temperature	7	2.3	0	0.0	7	1.4
Birds attack	13	4.3	9	4.2	22	4.3
Livestock	61	20.3	45	20.8	106	20.5
Other specify	5	1.7	3	1.4	8	1.6

Table A4: Causes of Sorghum losses during Threshing and Winnowing

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Wind	12	5.6	21	7.0	33	6.4
Grains remain in thresh due to improper or incomplete threshing	73	33.8	66	22.0	139	26.9
Grains remain in soil	8	3.7	5	1.7	13	2.5
Livestock	6	2.8	2	0.7	8	1.6
Birds	1	0.5	1	0.3	2	0.4
Other specify	1	0.5	4	1.3	5	1

Table A5: Causes of Sorghum losses during Grading and Bagging

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Grains spilling	19	8.8	52	17.3	71	13.8
Livestock	11	5.1	1	0.3	12	2.3
Other specify	1	0.5	4	1.3	5	1

Table A6: Causes of Sorghum losses during Storage

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Rot due to high moisture or rainfall	29	13.4	33	11	62	12
Aflatoxin/Mould	1	0.5	26	8.7	27	5.2
Insects and other pest	6	2.8	33	11	39	7.6
Rodents	0	0.0	14	4.7	14	2.7
Livestock	0	0.0	1	0.3	1	0.2
Other specify	0	0.0	4	1.3	4	0.8

Table A4: Causes of Sorghum loss During Threshing and Winnowing

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Wind	12	5.6	21	7.0	33	6.4
Grains remain in thresh due to improper or incomplete threshing	73	33.8	66	22.0	139	26.9
Grains remain in soil	8	3.7	5	1.7	13	2.5
Livestock	6	2.8	2	0.7	8	1.6
Birds	1	0.5	1	0.3	2	0.4
Other specify	1	0.5	4	1.3	5	1

Table A5: Causes of Sorghum Loss During Grading and Bagging

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Grains spilling	19	8.8	52	17.3	71	13.8
Livestock	11	5.1	1	0.3	12	2.3
Other specify	1	0.5	4	1.3	5	1

Table A6: Causes of Sorghum Loss During Storage

	Treatment		Control		Overall	
	Freq.	%	Freq.	%	Freq.	%
Rot due to high moisture or rainfall	29	13.4	33	11	62	12
Aflatoxin/Mould	1	0.5	26	8.7	27	5.2
Insects and other pest	6	2.8	33	11	39	7.6
Rodents	0	0.0	14	4.7	14	2.7
Livestock	0	0.0	1	0.3	1	0.2
Other specify	0	0.0	4	1.3	4	0.8

Appendix 4: Propensity Score Matching

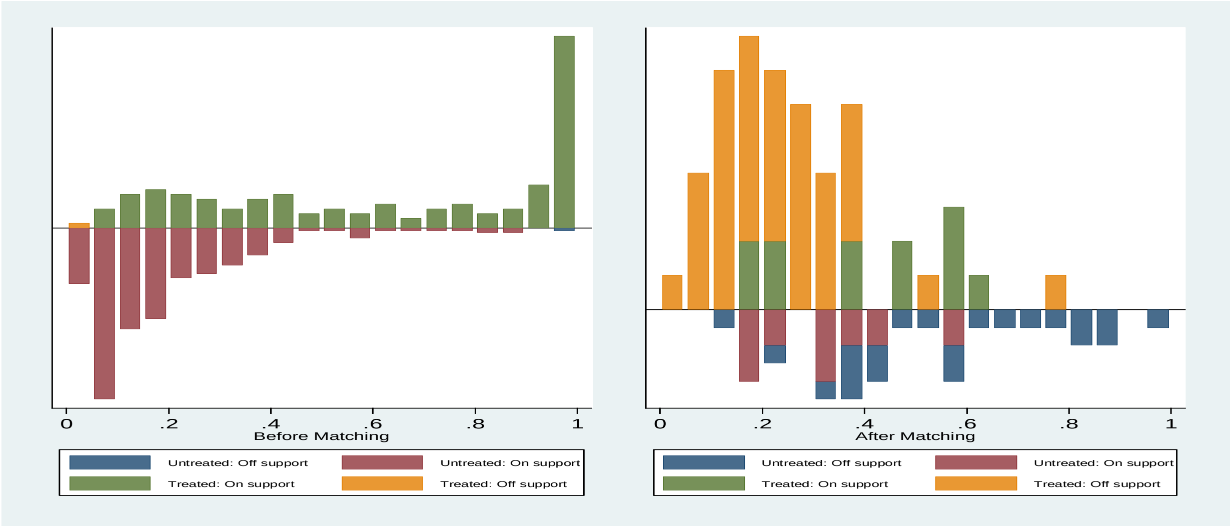

Figure A1: Distribution of Propensity Scores Before and After Matching

Table A7: Indicators of Matching Quality Before and After Matching

Outcome Variable	Pseudo-R^2 (Unmatched)	Pseudo-R^2 (matched)	Std. Bias (Unmatched)	Std. Bias (matched)	% reduct |bias|
Farm Profitability	0.361 (0.000)	0.344 (0.000)	158.7	158.2	30.3

Source: Survey data, 2015

Table A8: Sensitivity Analysis

	Treated		Control	
Critical Value (Γ)	On Support	Off Support	On Support	Off Support
1.32	131	1	251	1

Table A9: Quality Test of Matching Algorithm

Variable	Matched	Treated	Control	%bias	bias	t	p>t
Gender	U	0.713	0.653	12.8		1.43	0.153
	M	0.652	0.621	6.5	49.2	0.51	0.610
Age of farmer	U	46.648	50.097	-22.1		-2.46	0.014
	M	48.515	57.879	-60.1	-171.5	-5.34	0.000
Marital Status	U	0.870	0.833	10.4		1.16	0.247
	M	0.811	0.765	12.8	-22.7	0.9	0.368
Household Status	U	0.824	0.800	6.2		0.69	0.493
	M	0.826	0.841	-3.9	37.1	-0.33	0.742
Completed Basic	U	0.190	0.143	12.5		1.41	0.159
	M	0.159	0.136	6.1	51.1	0.52	0.604
Higher than Basic	U	0.171	0.080	27.8		3.19	0.001
	M	0.098	0.083	4.6	83.4	0.43	0.670
Household Size	U	5.630	6.163	-18.7		-2.07	0.039
	M	5.402	3.977	49.9	-166.9	4.9	0.000
Main Occupation	U	0.889	0.900	-3.6		-0.41	0.685
	M	0.886	0.939	-17.2	-377.3	-1.53	0.128
Farming Experience	U	5.796	9.137	-51.7		-5.46	0.000
	M	6.030	10.061	-62.3	-20.7	-5.12	0.000
Length of Stay in the community	U	28.949	34.637	-31.2		-3.47	0.001
	M	30.091	41.311	-61.6	-97.3	-4.37	0.000
Farm Size	U	1.032	0.688	51.2		6	0.000
	M	0.815	0.921	-15.7	69.2	-1.2	0.230
FBO Membership	U	0.625	0.007	177.7		21.66	0.000
	M	0.394	0.379	4.4	97.5	0.25	0.801
Access to credit	U	0.083	0.023	26.9		3.16	0.002
	M	0.045	0.106	-27.2	-1	-1.87	0.063

Number of Extension visits received	U	1.120	0.110	83.7		10.11	0.000
	M	0.409	1.030	-51.5	38.5	-4.57	0.000
Distance from community to main market	U	2.445	1.978	10.1		1.21	0.229
	M	2.562	3.347	-17.1	-68.3	-1.26	0.209
Leadership in social organization	U	0.218	0.097	33.6		3.87	0.000
	M	0.159	0.174	-4.2	87.5	-0.33	0.742

Appendix 5: LVI Results in Percentage for Control and Treatment

Table A10: LVI Sub-component Values and Minimum and Maximum Sub-components in Percentage for Control and Treatment

Major component	Sub-component	Control	Treatment	Max for Both	Min. for Both
Water	Percent of household reporting water conflict	27.67	36.28	100	0
	Percent of households that utilize a natural water source	74	86.51	100	0
	Average time to water source	8	10	60	0
	Percent of household that do not have a consistent water supply	46.33	59.07	100	0
	Inverse of the average number of liters of water stored per household	0.12	0.13	1	0.02
Socio-Demographic	Dependency ratio	0.94	0.88	7	0
	Percent of female headed household	22.33	18.14	100	0
	Percent of households where head has not attended school	76.33	65.12	100	0
	Percent of household with orphans	8	19.07	100	0
Food	Percent of households dependent solely on family farm for food	99.33	98.60	100	0
	Average number of months households struggle to find food	4	3	9	0
	Average crop diversity index	0.17	0.17	0.5	0.08
	Percent of households that do not save seeds	1.33	0.47	100	0
	Percent of households that do not save crops	7.33	7.44	100	0
Social-network	Average Receive: Give ratio	1.19	1.13	6	0.05
	Average Borrow: Lend	0.93	0.93	2	0.5
	Percentage of household that have not gone to their local government for assistance in the past 12 months	93.67	98.6	100	0
Livelihood strategies	Percent of households with family member working in different community	18.67	12.09	100	0
	Percent of households dependent solely on agriculture as a source of income	90	69.77	100	0
	Average agricultural livelihood diversification index	0.32	0.34	0.5	0.25
Natural Disaster	Percent of households that do not receive a warning about the pending natural disaster	95.67	91.63	100	0
	Percent of households with injury or death as a result of recent natural disaster	0.33	0.47	100	0
	Average number of floods, drought, bushfires events in the past 6 years	3	3	17	0
	Mean standard deviation of monthly average minimum daily temperature (years:1988-2013)	11.1	11.1	12.8	9

	Mean standard deviation of monthly average maximum daily temperature (years:1988-2013	17.83	17.83	19.97	15.38
	Mean standard deviation of monthly average precipitation (years: 1983-2013)	83.8	83.8	115.68	7.49
Health	Average time to health facility (foot)	24	26	180	0
	Percent of households with family member with chronic illness	9.33	12.56	100	0
	Percent of households where a family member had to miss work or school in the past 6 months	38	33.02	100	0
	Average malaria exposure*prevention index	1.83	2.17	6	0